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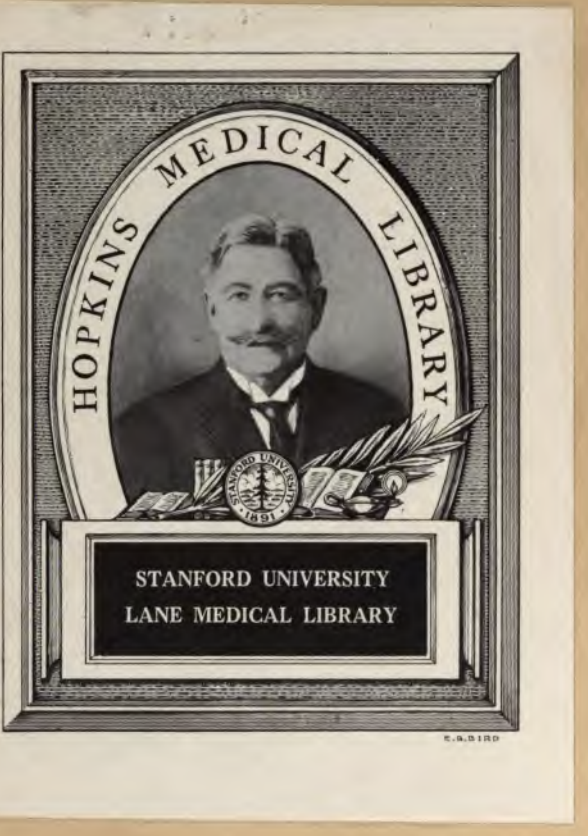

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ON LOCAL ASPHYXIA

AND

SYMMETRICAL GANGRENE OF THE EXTREMITIES.

BY

A. G. MAURICE RAYNAUD. 1834-81.

TRANSLATED BY

THOMAS BARLOW, M.D.

TRANSLATOR'S NOTE.

THE papers translated are (1st) Raynaud's original thesis, which was published in 1862, and (2nd) his last researches on the subject of local asphyxia, which appeared in the *Archives Générales de Médecine*, 1874, vol. i., pp. 5, 189.

An appendix has been added by the translator, containing references to the chief additions made by others to the knowledge of the subject subsequently to the publication of Raynaud's memoirs, but no attempt has been made to give a complete bibliography.

AUTHOR'S PREFACE.

To describe a new disease, and especially to give a new name to a group of symptoms which has been long observed and described, is assuredly less difficult than to link together under a common law which dominates them many affections apparently different. In the infinite variety of morbid phenomena which present themselves daily to our observation with a physiognomy always new, it is easy to choose here and there some exceptional facts and to constitute them a common type, omitting the differences which separate them in order to see only the points of contact between them. A little imagination suffices for this task, and positive science has little to profit by it. Also, in spite of the title which I have given to this thesis, I am bound to declare at the outset that I do not aspire to the frivolous and dangerous honour of making an innovation in pathology. My ambition would be rather to demonstrate that certain facts of gangrene of the extremities which one meets at long intervals in practice, and of which the strange appearance is apt to disconcert the most skilful, are in reality much less singular than one would be tempted to believe, and can be connected by intermediate steps with other facts much more common, and which only escape attention by their everyday occurrence.

Unfortunately words have, in nosology, an importance of which it would be useless to attempt to deprive them.

That which interests us in a given case is not to know in which genus and in which species it is proper to classify it, as we are in the habit of doing with objects of natural history; it is rather to discover by what series of deviations the normal

health has become altered up to this point, by what sequence of phenomena the malady once constituted might pass over into conditions still more grave. This is, in fact, diagnosis and prognosis, that is to say, more than the half of medicine.

But if we were bound to restrict ourselves to this rigorous order, medical language would be no longer possible, and it would be necessary to wait indefinitely until science should be constituted in all points. The best thing is, as a new variety offers itself for observation, to give it some name in accordance with the most striking characters, waiting for a future synthesis to suppress these provisional landmarks.

This is what I have decided to do, not without some repugnance. I have yielded to the natural instinct which leads us to seek under the brute facts for the interpretation which is most satisfying to the mind. It is hardly necessary to add that, if the future should demonstrate the falsity of my explanations, I hope that I should have enough enlightenment and sincerity not to attach any further importance to theoretical views inevitably more or less incomplete.

It always obtains that facts are facts, and that there can be nothing but advantage in grouping them together into a picture.

LOCAL ASPHYXIA AND SYMMETRICAL GANGRENE OF THE EXTREMITIES.

CHAPTER I.

GENERAL CONSIDERATIONS ON SPONTANEOUS GANGRENE.

I. "EVERYTHING concerning spontaneous gangrene is in a state of distressing uncertainty," wrote M. Victor François, of Mons, in 1832, in a work which has justly become classical;* and this acknowledgment of the gaps of knowledge upon this important part of pathology might at that time pass for the exact expression of the truth.

If it is permitted to medicine to conceive a legitimate pride in taking a general retrospective survey over its past, then assuredly it is well to do so in all that relates to the subject which is about to occupy our attention.

Since the above epoch, and thanks to the progress of pathological anatomy, much of the darkness has disappeared, a goodly number of positive facts have been added to knowledge, and if there remains still much to be done, at least the direction is indicated and the way opened. Amongst the writers who have contributed most to this progress, it is right to assign an honourable rank to the distinguished physician whom I have just cited; his work, based upon a considerable number of observations, is still the most complete treatise that we possess on the subject. Without pretending, as one would do him wrong in saying, that spontaneous gangrene has a vascular obstruction for its constant cause, M. François at least established on an extensive basis of statistics the very great frequency of this cause and sought to estimate its mechanism. That is certainly the most practical

* *Essai sur les gangrènes spontanées.* A work crowned in 1830 by the Soc. Roy. de Méd. de Bordeaux. Mons, 1832.

conclusion which results from his work. We must recognise nevertheless that he only established a truth already presented for several years, and many times even clearly announced before his time.

From the middle of the 18th century there had been a vague idea of the part which arteries play in the production of gangrene, and Quesnay in 1739 indicated as a very probable cause, that, which he called in his metaphorical language the extinction of the organic action of the arteries ;* but men were satisfied with that confused notion, which was spoiled directly by the humoral hypotheses on the congelation of the juices and fixation of the animal spirits, to which soon came to be added the inevitable accompaniment of the venereal and scorbutic poisons. We can retrace the steps of this confusion in the great work of Boyer, the successor and representative of the ancient Academy of Surgery ; too often in speaking of gangrene he fails in that precision which is habitual to him.

Nevertheless, and already in his time the idea of a direct obstacle to the course of the blood having its seat in the interior of the vessels came to the front. Definitely stated by Hébréard in 1817,† taken up and developed two years afterwards by Avisard,‡ this idea, which was so obvious, henceforth impressed a new direction on research. Unfortunately there happened in this subject what almost always occurs in subjects of study : two distinct things were confounded, viz., ossifications of the arteries and blood concretions in the cavities of vessels ; hence arose many misunderstandings.

Meanwhile the physiological doctrine, which shone then with all its brilliance here as elsewhere, made its influence felt ; it had the good fortune to find support in the great authority of Dupuytren. Although M. Roche has claimed subsequently, and with reason, the paternity of arteritis, this malady held such an important place in the teaching of the celebrated surgeon of the Hôtel Dieu that he has preserved in great measure the glory and the responsibility of it. Arteritis, a simple question of fact at

* *Traité de la Gangrène.* Paris, 1749.

† "Memoire sur la gangrène ou mort partielle, considérée dans les divers systèmes anatomiques qu'elle peut affecter," dans les Mémoires et prix de la Société de Médecine de Paris, 1817.

‡ "Observations sur les gangrènes spontanées ou par ossification et oblitération des artères." *Bibliothéque Médicale*, 1819.

first, then soon a question of doctrine, took a prominent place in general pathology. From it was demanded the key, not only of local phenomena, coagulations, ossifications, &c., but of important general states (the inflammatory fever of P. Frank, the angeiotenic fever of Pinel) which formed a new source of dispute. We cannot affirm that all the questions then raised have been resolved. Nevertheless, disengaged from the hypothetical surroundings with which it has too often been surrounded, the arterial phlegmasia, either as cause or effect, has a demonstrated existence; to deny it, as they have recently attempted to do in Germany, is to go against evidence. Whilst discussion lost itself in this polemic, in which people were not in accord either on words, or things, or symptoms, or lesions, two modest theses were maintained at Paris which at first attracted no attention, but which subsequently it was found necessary to reconsider. One bore this title: "Researches on a little-known form of occlusion of arterial vessels considered as a cause of gangrene."* The author, M. Allibert, gave expression to this original idea: that the inflammation under discussion might be only the effect, and not the cause, the primitive fact being the coagulation of the blood in its vessels. The other thesis,† of a little earlier date, was that of the lamented M. Legroux. Limiting his ambition to a still more restricted scale, this observer devoted himself to a careful anatomical study of arterial concretions taken by themselves, a study which he pursued all his life, and upon which he published his last word a short time before his death.‡

This was the true path. Subsequently many works were produced relating to the formation of clots *in situ*, to modifications which may occur in their intimate formation, and to the effects produced by their migration in the circulatory current.

Of all these works the most important, without contradiction, are those of the celebrated Virchow, upon solid bodies transported to a distance by the blood current, and to which he has given the name of embolisms.

Embolism has had the lot of many discoveries: once the fact demonstrated, and the principle laid down, it is perceived that the same phenomenon had been not only seen, but interpreted

* *Thèse de Paris*, 1828, No. 74.

† "Concrétions sanguines dites polypiformes développées pendant la vie." *Thèse de Paris*, 1827, No. 215.

‡ "Des Polypes artériels (concrétions sanguines)," Gaz. hebdomadaire, 1860.

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in this sense by different authors. M. Legroux had recorded an example of it in his thesis; M. V. François had cited a second example of it.* Still further the same idea has been found clearly expressed even in the *Sepulchretum* of Bonet and the *Commentaries* of Van Swieten. But this is of little importance. Far from diminishing the merit of M. Virchow, these facts ought simply to pass for an anticipated confirmation of the views of the eminent Berlin professor who, by the numerous experimental proofs with which he has supported his theory, by the extension which he has given to it, deserves to be considered as its veritable founder.

Conclusive facts have been produced in this sense by M. Schutzenberger.†

Finally, my learned teacher, M. Gubler, and quite recently M. Ball,‡ have completed the demonstration, by making it clear that fragments of clots found in very remote parts of the circulatory system can nevertheless be adapted very exactly one to another in such a way as to permit the primitive clot to be reconstituted. To-day we may say that embolism has gained its cause, and there remains nothing more to be done except to defend it against its own excesses.§ But if we consider it along with arteritis, we cannot but find between these two maladies the greatest resemblance as to their effects. Both present this common condition: the interference at first with the supply of a sufficient quantity of oxygenated blood in a given area of the arterial system. On the other hand, the study of the anatomical lesions presented by the nervous system has for a long time been made from the point of view of gangrene. In an excellent memoir, published in 1836, M. Godin has rendered‖ the view extremely probable that most gangrene has for its cause a venous obliteration, and ought in consequence to be brought into proximity with the œdemas; it is almost generally admitted to-day that venous obstruction, although incapable by itself of determining gangrene on account of the great number of anastomoses, has at least the power of modifying its character.

* *Op. cit.*, p. 202.

† "De l'oblitération subite des artères par des corps solides," &c. *Gaz. Méd. de Strasbourg*, Feb. 28, 1857.

‡ *Thèse de Paris*, 1862.

§ Vide *Klinik der embolichen Gefäss-Krankheiten.* Berlin, 1861.

‖ *Archives générales de Médecine*, 1836, 2e Serie, T. xii., p. 52.

II. From all that has preceded there would therefore appear at present to result an almost complete certainty touching the mode of production of gangrene. The general law might be formulated in these two equations: arterial obliteration=dry gangrene; venous obliteration coinciding with arterial obliteration=moist gangrene. This is the opinion which has recently been ably defended by M. Béhier.* Everything is so satisfactory, everything is so logical from this point of view, that in truth it would be very desirable that such should be the case if anything were desirable in the matter of science other than knowledge of the truth.

But Nature does not accommodate herself so easily to our systematic views. There still remain the spontaneous gangrenes, which it would be premature to introduce into one or other of these groups. Perhaps with the spontaneous gangrenes, the gangrenes of the mouth and vulva in children may be associated. Does the gangrene produced by ergot of rye depend upon a material obstacle to the course of the blood? It is at least necessary to prove this, and on the other hand during the last few years new facts have been brought forwards which may modify our views in this respect.

We know that M. Bourgeois, of Etampes, has sought to establish that dry gangrene of the limbs may occur as a complication of typhoid fever,† and he believes so strongly in the union of these two conditions that he does not hesitate to propose for this variety the name of typhoid gangrene. It is true that M. Béhier responds by a verdict of not proven, and contests the exactitude of the diagnoses made by M. Bourgeois, who in his opinion has taken for typhoid that which was only the commencement of gangrenous symptoms.‡ It must be admitted that the facts cited by M. Bourgeois are too incomplete for a definite conclusion to be deduced from them. The state of the arteries is not noted, and no autopsy is recorded. Nevertheless one is most reluctant to admit an error of diagnosis on the part of a physician so distinguished as M. Bourgeois.

Perhaps a distinction should be drawn between the fact and

* "Lettre sur la gangrène typhoide." *L'Union Médicale*, Oct. 22, 1861.

† *Archives générales de Médecine*, 5e Serie, T. x., p. 149.

‡ Rapport lu à la Société médicale des Hopitaux par M. Béhier. *L'Union médicale* 13 Juin, 1857.

the interpretation. The fact, was gangrene supervening on typhoid fever; the interpretation was the theory proposed by the author, of a gangrene caused by a vital inscrutable action, by a kind of metastasis. Without having recourse to these explanations, which are a little mystical, might one not to admit, since typhoid fever is frequently complicated with sloughs on the sacrum, and since pressure of itself is alone insufficient to explain them, that dry gangrene of the limbs might also occur? When moreover we think of the excessive readiness with which coagula are formed after long illnesses, whatever their nature, we come to believe that it is sufficiently probable that blood concretions may form in the same way in the course of a malignant fever, all the more so that the facts of typhoid gangrene are not without examples in the history of science.* Thus this variety comes within the general law, and this is what seems to result from the new cases which have been since observed.†

But the same thing does not hold, at least at present, with regard to the diabetic gangrene described by M. Marchal (of Calvi), and upon which the former professor of the Val de Grâce has insisted for many years.‡ The nature of the lesions, the progress of the symptoms, the inflammatory appearance which precedes mortification, all seem opposed to the idea of a vascular obstruction. If these already numerous observations are confirmed (M. Marchal possesses now more than forty of them) it will become necessary to admit a new variety.

Finally, here is a statement which is not less disturbing for the vascular theory when stated in a too absolute manner:—

M. Virchow, the great promoter of the doctrine of thrombosis and embolism, after having described ordinary mummified gangrene, declares that the so-called senile gangrene differs from it entirely.

As his opinions on this point are little known in France, and as his authority is more often invoked than his writings read, I ask permission to cite from them a few passages:—

* *Vide* Panaroli Jabrolog, *Pentec. quinque.* Hanov., 1654. Hildenbrand has recorded many cases of gangrene of the extremities in typhus. *Vide* also La Motte, *Observations chirurgicales*, T. iii., p. 346.

† Trousseau, *Clinique médicale de l'Hôtel Dieu*, T. i., p. 210.

‡ *Vide* "Remarques historiques sur la gangrène diabètique." *L'Union médicale*, 25 Juillet, 1861.

"Senile gangrene differs essentially from the preceding (mummific gangrene) and from that which we have described as spontaneous gangrene. It is quite erroneous to suppose that it is regularly preceded by arterial thrombosis. I have had frequent opportunities of examining it anatomically, and often I have been unable to find any trace of diminution of the calibre of the arteries, not even above the limits of the gangrene. Often, it is true, the arteries are found diseased, sometimes hardened, sometimes atheromatous or calcareous, &c. Nevertheless I do not consider these lesions as a sufficient cause, because it is recognised that very extensive degenerations of arteries may exist without gangrene. It is very important to examine at the same time the condition of the muscular fibres of the heart; it may be atrophied, or have undergone fatty degeneration. Circulation becomes difficult in the remote vessels, particularly in the lower limbs; nutrition suffers, &c. Senile gangrene is therefore essentially a necrosis from feebleness, and ought to be brought into proximity with gangrene following upon decubitus, and with those gangrenes which supervene in the ultimate phases of grave fevers, and affect the ears, the nose, the fingers, and the toes."*

We see that the last word has not yet been said on the subject of gangrene, and on dry gangrene in particular. In the actual state of our knowledge, and in order to avoid confounding in a single description facts perhaps very incongruous, it becomes more and more necessary to give up an artificial unity which can only satisfy minds who care little for new researches; also it is necessary to establish in the history of gangrene divisions based upon pathological anatomy and etiology, and to study separately each of these varieties, subject to the bringing them together at a later period and discovering the bond which unites them and the law which dominates them.

III. It is to this work of analysis (of which the attentive reading of modern works on gangrene has made me strongly feel the necessity) that I wish to contribute my part. I pro-

* Virchow, *Handbuch der speciellen Pathologie und Therapie*, T. i., p. 289. There are many reservations to be made to the explanation given by M. Virchow. The degeneration of the heart and that of the vessels seem to me to be inseparable lesions, and it appears to me difficult to understand how a permanent and incurable cause, like that of cardiac atrophy, should produce effects which are often transient, and also difficult to explain cases which are followed by recovery.

pose to demonstrate that there exists a variety of dry gangrene affecting the extremities which it is impossible to explain by a vascular obliteration—a variety characterised especially by a remarkable tendency to symmetry, so that it always affects similar parts, the two upper or lower limbs, or the four at the same time; further, in certain cases, the nose and the ears; and I hope to prove that this kind of gangrene has its cause in a vice of innervation of the capillary vessels which it remains for me to define.

As may be seen, it is a very limited corner of the general history of gangrenes that I propose to consider. That history I shall avoid even approaching; it would be an immense task, and I cannot forget Horace's line, "Quid ferre recusent quid valeant humeri." I wish to state at the beginning that I do not pretend in any way to attack the theory generally admitted, of gangrene by obliteration; I believe it to be perfectly established in the majority of cases. At least, in presence of the innumerable difficulties which encumber Science, let us know how to respect the facts which are irrevocably acquired by her!

Few works have been undertaken up to this time from my own point of view. It is true that many authors have maintained, rather on theoretical grounds than on the basis of exact observations, the possibility of a gangrene occurring from the very fact of a nervous lesion; innervation having according to them an influence upon the phenomena of nutrition at least equal to that of circulation.

One of the most interesting memoirs in this sense is the thesis of M. Zambaco, which bears this significant title: "Spontaneous gangrene produced by nervous perturbation." But M. Zambaco is wrong, in my judgment, in generalising the cause too much and not precisely stating the mechanism. He admits the direct and primitive influence of the nerves on nutrition, which is far from being demonstrated by physiology; consequently he believes that the nervous system disturbed or damaged in its functions can by itself alone determine gangrene without any lesion of the vessels. He goes so far as to maintain that the nervous element predominates in all gangrenes, which is inadmissible. The greater part of the facts gathered by him relate to lunatics, and especially to patients affected with

general paralysis; as if in the last case paralysis and gangrene were not allied to profound and general lesions of nutrition very different from a simple neurosis. These facts have at least the incontestable merit of establishing this capital point, that there are *gangrenes without alteration of vessels.*

I have found valuable indications in a very remarkable memoir by M. Charles Racle, entitled, "Memoir on some new characters of gangrene, and upon the existence of this lesion in maladies in which it has not yet been described."* The chapter entitled "Gangrene with nervous phenomena" contains some passages which so closely resemble some of my own observations that I cannot doubt that M. Racle has had before him similar cases to those which I have recorded. He insists on the constant limitation of this gangrene to the skin, on the white horn-like aspect which the external tegument takes in these circumstances, and upon the integrity of the general health which frequently accompanies the appearance of this malady.

These remarks are obviously the result of exact observation. I learn moreover from the brother of the author, who is at present physician of the Hôpital des Enfants Malades, that the material for this memoir had been gathered in that institution, and that M. C. Racle had been impressed like myself with the symmetry of the gangrenous lesions. Unfortunately this work remains unfinished, so that many features which are easily recognised when one has observed them oneself remain enigmatical for those who have not had the living picture actually under their eyes. Before tracing the history of the malady which makes the principal object of this study, I believe it necessary to discuss in some measure, spontaneous gangrene considered by itself, and independently of the lesions which can give rise to it. It is the necessary preamble of what I have to say upon the particular variety with which we are concerned.

IV. *Pathological Anatomy and Physiology of Spontaneous Gangrene.*

Almost all authors who have written upon gangrene define it as "a partial death." A crowd of variations or circumlocutions have been proposed in place of this brief exposition of the

* Published in the *Gazette médicale de Paris*, 1859.

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phenomenon. But the basis of them always rests on the same doctrine. The more we reflect on this definition, the more unsatisfactory or even erroneous we find it. It is insufficient, because it explains neither the appearance nor the mode of evolution of gangrene. It is erroneous, because we assume thus a term of comparison which is far from being always exact. I go into an amphitheatre and detach there a limb of a corpse; everybody will admit that the limb is dead, and yet it is very certain that it is not, and has never been gangrenous. To say that gangrene is a partial death is in truth to say nothing at all, and to content oneself with mere words. If we understand thereby that a part more or less extensive ceases to belong to the organism, this definition will apply to conditions which have nothing in common with what is generally designated by gangrene. And it will be necessary at once to include all those morbid states to which have been given in Germany the name of necrobiotic processes, a somewhat *bizarre* term, which means simply an interstitial process tending to the more or less complete destruction of the histological elements of a tissue. Further, may not the purulent disintegration of a living part, from one point of view be regarded as a partial death? And without even leaving the domain of physiology, may we not consider that the epithelial desquamation which takes place incessantly on the surface of the skin and of the mucous membranes has for its normal tendency the elimination of a certain number of elements which have belonged to the organism, and which cease to belong to it?

It is sufficient to consider attentively a limb affected with dry gangrene to be convinced that there must have occurred something very special; the shrivelling up of the tissues, the horny aspect, the woody hardness, the ebony black colour, give to the skin, the aspect of an Egyptian mummy or of a piece of gutta percha. It is impossible that these characters should have been produced all at once, and we must assume the intervention of one of the most complex of pathological processes.*

There are only two alternatives: either the simple fact of the removal of a limb from the influence of vital forces may

* The definition of the *Compendium de Chirurgie*, written in this spirit, appears to me the only one which approaches the truth. *Vide* T. iv., p. 236.

suffice under the influence of physico-chemical laws to produce mummification; or this phenomenon (which is not produced normally upon a corpse, in which putrefaction always precedes desiccation), is the effect of a morbid evolution of a quite special character, and deserves to be studied as much as the inflammatory process.

I hold that there was something fundamental in the distinction established formerly by Galen, and subsequently by Fabrice de Hilden, between gangrene and sphacelus, a distinction revived and definitely stated in our days by Thomson.* From this point of view gangrene would be none other than this morbid evolution of which I have spoken; sphacelus would be the confirmed and irremediable condition. Unfortunately usage has prevailed in employing the two words as synonymous. After all it is of little importance to give a definition of gangrene, and it is even doubtful whether it is possible to give a sufficiently comprehensive one in the actual state of knowledge. That which is more interesting is to unravel what passes in the interior of a tissue which undergoes this alteration. It is this which I am about to attempt, restricting myself to dry gangrene.

V. M. Cruveilhier was I believe the first to fully describe the variety which he calls gangrene by cadaverisation. It presents the greatest analogies, if not a perfect identity with what Quesnay called white gangrene.† The dead parts present themselves under the aspect of those of a fresh corpse, or of a limb which has just been amputated. This form is always accompanied by algidity (corpse-like coldness), and by a colour which is very striking (the colour of the corpse), and quite distinct from that of the adjacent parts. The epidermis is easily detached by friction. This symptom is observed especially in the cases where the death of the limb has taken place instantaneously without prodromata, in consequence of the complete and sudden interception of the arterial blood.‡

M. Cruveilhier admits that cadaverisation, which may be considered, according to his view, as the first period of gangrene, is soon followed by the second period, which is at one time dry,

* *Lectures on Inflammation.*

† *Op. cit.*, p. 337 and p. 348.

‡ *Anatomie pathologique générale*, T. iv., p. 252.

at another moist.* This may be true in certain cases. But we must recognise fully that these cases are infinitely rare, and the important part which subsequently the learned professor rightly apportions to venous and lymphatic absorption in the process of mummification, proves indeed that, as a usual thing, he does not himself believe in the instantaneous character of death of the extremities.

We may admit that in these exceptional cases, desiccation when it occurs is a simple physical phenomenon, to which the means employed for treatment greatly contribute; the glacial cold which seizes the extremities leads naturally to the placing them in an elevated temperature, and the very active evaporation which ensues therefrom is responsible for much in the artificial result which is obtained. Desiccation then ensues, a kind of tanning process, which is quite comparable to what takes place in an anatomical specimen which has been stoved in order to preserve it. The tissues lose their transparency, take on a brownish drab opaline colour, and can then be preserved indefinitely. In such a case the word mummification is true to the letter; because it is identically that which has taken place in the limbs of the Egyptian mummies.†

M. Czermak, who has studied microscopically the tissues of one of these mummies, dating from more than three thousand years back, has found them so perfectly preserved that they might have been supposed to be taken from a living body.

But I cannot too strongly state that this is not what we observe in the ordinary cases of dry gangrene. The external aspect is not the same; the skin assumes at the outset a violet tint, which deepens more and more, passing soon into a colour as completely black as that of the sloughs produced by a burn of the sixth degree. This condition resembles nothing that we are acquainted with; we are compelled therefore to admit a progressive modification in the intimate structure of the tissues. This modification, which, according to my view, is gangrene *par excellence*, is so far a vital phenomenon that it affects by preference the most living parts, and on the contrary the parts least endowed with vessels and nerves—those, in one word, which have least vitality, like the tendons, ligaments, aponeuroses

* *Ibid.*, p. 258.

† In these cases especially the epithet of partial death would be convenient.

are precisely, as I shall show, those which resist gangrene the best.

VI. The most complete work, and, to speak truly, the only one which we possess on the alterations of the tissues in gangrene, is of quite recent date.* The author of this interesting memoir, M. Hermann Demme,† has perhaps erred in studying gangrene as a separate morbid entity, and in placing on one and the same plan all the lesions of whatever form and to whatever tissue they belong. There results from this method a certain confusion inseparable from descriptions which are too general.

There are to be found, nevertheless, useful facts bearing on the subject with which we are concerned.

M. Demme considers gangrene as characterised by the tendency to decomposition of the immediate complex principles, and to the formation at their expense of binary compounds (water, carbonic acid, ammonia), besides sulphuretted and phosphoretted products. But according to his view all these new combinations are not produced with the same rapidity; in the cases where there is no preservation a progressive carbonisation occurs, which depends on an incomplete combustion of carbon, whilst the transformation is infinitely more rapid of nitrogen into ammonia, and of oxygen and hydrogen into water; to this it would be necessary to add desiccation. M. Demme, we ought to say, only presents these theoretical views as hypotheses, without supporting them by any experimental proof; he does not explain, moreover, the cause which would produce this slowness in the production of the phenomena. Now this is the whole question, without which the evolution of gangrene does not differ from the purely chemical process which constitutes putrefaction. I shall soon have occasion to return to this.

Passing then to microscopic alterations, which are the true object of his memoir, M. Demme divides them into three kinds: 1st. Elements which are found only in the gangrenous tissues and not in normal tissues (fat of new formation, pigmentary deposits, crystals which are not found in the healthy state, parasitic organisms either vegetable or animal). 2nd. Alterations in consistence of the normal histological elements. 3rd.

* I cite simply to note them, the incomplete observations [illegible] and Martino.

† *Ueber die Veranderungen der Gewebe durch Brand.*

Amorphous masses of substances more or less carbonised, the ultimate products of gangrene.

The most remarkable and the most constant of the elements of new formation is the fatty matter, the abundance of which in the gangrenous tissues had been pointed out since 1847 by Vogel and Michéa, such an abundance, obvious to microscopic examination, that it is impossible to explain it by the mere liberation of the fat existing in the normal condition, and that one is led to admit *ipso facto* the transformation of the proteid matters into fat. This hypergenesis of the adipose elements shows itself primitively in the cells. The nuclei are surrounded with refracting vesicles, and the walls become granular and break, thus letting the contents escape into the parenchyma.

In the second place, and this is the most original part of his work, M. Demme describes with great detail a series of pigmentary formations which may be the principal cause of the morbid colour of the tissues. The most important of these elements constitute that which he designates, with Valentin, by the name of gangrenous corpuscles. Under a power of 75 diameters these corpuscles appear as small black incommensurable points. Under a higher power they are found to be irregular bodies, which never take on a definitely crystalline shape. They are insoluble in alcohol and ether, which distinguishes them from fat; they are unaffected for the most part by acids and bases. Hydrochloric acid has the property of blanching them a little. Along with these so-called corpuscles there is found a variety of rust-coloured pigment, specially distributed in the vascular tissues and in the muscles. These bodies are distinguished from the preceding by their colour, by their granular surface, and by their slightly larger size. They are probably formed of hæmatosine. In the neighbourhood are found crystals of hæmatoidin, which differ chemically by the absence of iron. A third kind of pigment is formed by the sulphide of iron, the appearance of which is to be explained by the action of sulphide of ammonium on the red corpuscles. Add to all these, fine dark granules endowed with the Brownian movements, débris of cells with the aspect of colouring matter (pseudo-pigmentary cells), black masses remarkable for their resistance to all reagents, and which are formed *in situ* in the thickness of the

fibrous tissues, and you have nearly exhausted the already long list of these pigments.

The addition of an alkaline liquid to these deposits singularly favours the formation of a crowd of crystals (salts of fatty acids, carbonates, sulphates, phosphates of lime, ammonium, and soda, urates, butyrates, &c., &c.). This has only a moderate interest for us, the only crystals which we find present in mummified gangrene being needles of margarine and tablets of cholesterine, which are present only in minute quantity.

The remainder of M. Demme's work is devoted to the study of a crowd of parasites which have nothing special in them, and to alterations of the primitive elements of the tissues characterised especially by softenings, by granular conditions, by exudations of different kinds, in one word, a process of involution bearing at the same time upon almost all the derivatives of the cell. As this description includes both dry and moist gangrene, and even simple softening, there results from it for us very little practical instruction. Such is this work, of which I have given a detailed summary in order to allow it to be judged as a whole.

Whilst rendering full justice to the many ingenious views stated by the author, and to the conscientious exactitude which has characterised his observations, I fear that the result of his researches will only complicate the question by creating new species. "Entia non sunt multiplicanda sine necessitate." All these numerous varieties of pigments which we have seen described in detail what are they definitively? Products more or less advanced of the effusion and of the decomposition of the colouring matter of the blood. M. Demme recognises this implicitly. But why then not deduce this general conclusion? And especially why give to these products, which have neither constant form nor special seat, the name of pigment, which has in general anatomy a well-determined signification?

With the object of controlling the statements of the young and learned histologist of Berne I have of late neglected no opportunity of studying morphologically the tissues affected with dry gangrene, and whilst verifying the greater number of the facts advanced by M. Demme, [illegible]
me to be possible to simplify them co[illegible]
has moreover led to my discovering [illegible]

appears useful to mention now. The results which I am about to state were submitted to the competent control of my friends MM. Luys and Chalvet, whom I wish to thank for the help which they have given me.

VII. When we examine attentively an extremity affected with dry gangrene, that which strikes us at first is the perfect preservation of the external form. The rows of the papillæ of the skin are even more apparent than in the normal condition, on account of the thinning of the epidermis. On making transverse sections we find sometimes, immediately under the cutaneous envelope, small dark grains of irregular form of the size of a pin's head which are easy to enucleate. Seen by reflected light they appear of the most beautiful black; they are so hard that they rebound when we let them fall on a solid body; they might be taken for small morsels of charcoal. Nevertheless these grains are none other than blood concretions. When with some difficulty a section has been obtained sufficiently thin for microscopic examination, this section seen as a transparent object appears of a beautiful red. Treated by ether, thin fragments of this substance dissolve and communicate to the liquid a rose tint. There remains in the preparation an infinite number of irregular granules less refracting than fat, and which have all the characters of broken-up albumen. Let us proceed now from the surface to the deeper parts.

On examining detached portions with the point of a scapel, under the microscope there is to be seen, amongst cells and débris of epithelial cells more or less altered, a certain number of free fatty vesicles and of small masses of dark tint with very definite outline. These are, if one is not mistaken, the gangrenous corpuscles represented in the work of M. Demme. The colour varies from clear brown to black, without its being possible to establish between these varieties a precise limit. It is easy to recognise in them the appearance of effusions of colouring matter of the blood such as are to be found in a crowd of pathological conditions.

It is much to be feared that the gangrenous corpuscle will be regarded in the same way as the inflammatory corpuscle of Gluge and the famous cancerous corpuscle; that far from making of it a specific element, it will be possible to regard it as none other than one of the divers alterations of the normal tissues.

The triangular or spherical appearance which these bodies sometimes present ought not to deceive. It is very probable that these are not simple patches of blood colouring matter, but that they are the débris of regular elements soaked with the colouring matter of the blood, and which, although stained thereby, have preserved the whole or part of their primitive shape. We shall see directly how clearly this is the case with regard to the fusiform bodies of the fibro-plastic tissue. As to those bodies which present a definitely black colour and a great resistance to reagents, is it possible that they are granules of pure carbon? Many considerations tend to make us believe this, but we must not hasten to conclude that their origin is for that reason different from the other. Let us limit ourselves at present to the proposition that from most characteristic patches of blood colouring matter up to the most definite gangrenous corpuscles, there are only insensible transitions.

What is the cause which thus leads to the transudation of the colouring matter of the blood? It is often easy to find in a granular degeneration of the capillary vessels of the region.

On microscopic examination we may see a commencing disappearance of the finest vessels of the papillæ of the derma with infiltration of blood colouring matter into the surrounding tissue. In a more advanced condition all trace of vessels has disappeared, and the stroma of the derma presents a uniformly reddish-brown coloration. On further investigation we find that the papillary tissue has itself become granular.

But sometimes the malady having progressed rapidly, coagulation has taken place spontaneously in the interior of the last venous radicles, which then present under the microscope the appearance of a vascular network, richly injected.

This occurs especially in the variety of gangrene which I shall discuss subsequently in detail. The arteries remaining permeable, this fact is not contradictory to the assertion made formerly by Hourmann, who saw in his cases at the Salpêtrière injections made upon corpses penetrate abundantly and easily into all the gangrenous parts. Hourmann deduced therefrom the existence of a gangrene due to simple atony of the capillary circulation.*

* "Leçon orale de concours pour la chaire de pathologie interne." *Gaz. médicale de Paris*, 1840, p. 32.

In this case the presence of patches of blood colouring matter can be explained either by small ruptures, or by gradual imbibition through the walls of the vessels.

The facts which I have just expounded, suffice to explain in great part the black coloration of the affected tissues in dry gangrene. Nevertheless this cause is not the only one. With regard to this matter I have observed the following: on a foot presenting a complete type of mummified gangrene (absolute blackness and hardness), and which in spite of the already ancient date of death was in a perfect state of preservation, I was much surprised, whilst making a section perpendicular to the axis of the limb, to find below a layer of skin which was quite black the deeper tissues coloured red, of a very marked carmine tint.

I believed at first that here again there was a true imbibition of colouring matter of the blood, but microscopic examination of the portion soon undeceived me.

Under a low power (20 diameters) the derma as well as the fibrous tracts extending from its deep surface were seen to be of a beautiful rose colour, which deepened at certain points. Consequently the black colour of the derma depends solely on the greater condensation of the tissue. Its true colour does not differ sensibly from that of the subjacent parts.

The fatty cells contained in the areolæ of the connective tissue were found to possess also the same colour. But they had undergone another modification not less curious. They were completely emptied of their contents, and their walls pressed one against another had taken by juxtaposition a polygonal figure, simulating the aspect of the cellular tissue of vegetables. Under a higher power (210 diameters) this arrangement was very obvious. The polygonal cells not enclosing any granular contents presented a rose coloration, which was disseminated in patches, more marked in certain spots without being limited to any cell in particular; it was a kind of general suffusion. In order to be convinced that this colour belonged to the walls of the cells, an exceedingly thin section was made and examined under a higher power (500 diameters). The interior was found completely transparent, whilst the point where the walls were in juxtaposition, and which at the same time offered a greater thickness, presented only a rose tint. A few cells contain

scanty fatty vesicles, traces of their former contents, or crystals of margaric acid.

This rose colour did not dissolve in ether. This liquid carried away the vestiges of fat, and the colouring matter remained intact in the meshes of the substratum. When a fragment of tissue thus coloured was treated with cold water the fat was again withdrawn, and under the influence of ebullition the rose colouring matter took on a yellowish tint. Caustic potash dissolved the fat, the liquid assumed a milky appearance, and the colouring matter which remained became of an ochre colour. Under the influence of hydrochloric acid the colouring matter was withdrawn, and the substratum beame shrivelled.

All these reactions lead me to conclude that the colouring matter in question differs essentially from hæmatosine, which has for its principal characters its solubility in ether and its insolubility in water.* It is indeed only slightly probable that it may be a product of the transformation of hæmatosine; it approaches much more closely to what we obtain by the action of nitric acid on albumen.

I have only once had the opportunity of observing muscles affected with dry gangrene. I have found a very marked tendency to the disappearance of the striation of the primitive bundles, and in addition a very great number of disseminated patches of blood colouring matter. In the fibrous tissues (tendons) two kinds of alteration may be produced. In one form there is a complete preservation of the cells of the tissue, with infiltration of these cells by a reddish yellow colouring matter. If they are treated with nitric acid, at the moment when the acid penetrates, a crowd of small black granules escape from the preparation; these are probably the débris of the walls. The contents, when liberated, become aggregated into darkish disseminated masses, which cannot be confounded with imprisoned air, because they preserve here and there traces of their former colour. In other cases there is a true fatty substitution. The fibrous or fibro-plastic elements have totally disappeared. There only remain fatty cells, disposed in longitudinal series, which recall the former direction of the fibres of the tendon. I have obs[illegible]eous tissue which differs sensibly fr[illegible]ervous twigs, they were

[illegible], t. ii., p. 623.

already so far thinned away in the parts which I had occasion to examine that their alterations appeared to me to elude microscopic study.

I conclude with one remark: in the variety of gangrene which I am about to discuss, and in the case in which the lesion is limited to the skin, we see a kind of bulla form which on drying up takes a deep brown colour. It would be easy whilst looking at these bullæ with the naked eye to regard them as being formed simply by epidermis raised up by serum. I must, however, anticipate by saying that this is not altogether accurate.

In such a case there is a true superficial gangrene, limited to the papillary region of the derma. This appears clearly on the vertical section of one of these thin sloughs. The serum effused is therefore situated not between the epidermis and the derma, but between the deep part of the latter and the slough. To sum up: anatomy has shown us—1. Different histological elements in process of involution; 2. A notable increase of the fat; 3. Different effusions of colouring matter of the blood more or less altered, in the skin, epidermis, subcutaneous cellular tissue, and muscles; 4. A staining of the connective tissue and of the fatty cells by a true colouring matter.

It is to these two last causes combined that we must attribute the dark colour presented by the gangrenous tissues, seen by reflected light; joining to them perhaps also the leaden aspect which desiccation gives to all the organised tissues, independently of all pathological modification.

VIII. It was interesting to complete these results by a chemical study of the tissues attacked by gangrene; all the more that this inquiry, which had been stated more than once to be one of the desiderata of science, had never been really made up to now.

Struck especially by the remarkable resemblance of the gangrenous tissues to tissues carbonised by physical or chemical action, I wished to learn whether this resemblance was only external, or whether it expressed the real state of things? I submitted these views to M. le Dr. Reveil, professeur agrégé of the Faculty, who has been so good as to undertake a series of comparative analyses referring to both healthy and gangrenous tissues.*

* I ought equally to address my best thanks to M. Callman, interne in pharmacy at the Children's Hospital, for the minute care given by him to the details of these delicate experiments.

My principal object was, 1. To ascertain if chemical analysis confirmed the presence of excess of fat revealed by the microscope; 2. To ascertain the quantity of carbon contained either in the proteid matters taken separately, or in the whole of the organic materials (proteid and fatty matters), in order to find out definitely whether gangrene leads to an augmentation in the relative quantity of carbon or not.

For this purpose I chose as far as possible similar regions, either on the same subject or on subjects of the same age, in order to compare them in the healthy state and in the state of gangrene.* I deprived them very completely of the osseous particles which they contained, in order that the residues of the calcareous salts might not lead to a cause of error in the estimations. It was most important to obtain similar conditions throughout; the principal obstacle was in the quantity of water impregnating the tissues, a quantity which it was impossible to foresee, since it depended on the state of engorgement of the parts, and on the evaporation, which might vary considerably. It seemed to us that this inconvenience might be avoided, and that one might arrive at comparable results by proceeding in three series of operations: 1. To place the parts to be analysed in the stove at a temperature of 60° C. for several days, until desiccation should be complete, weighing them before and afterwards; 2. To treat them with ether until the fat disappeared, the difference giving the weight of fatty matter; 3. To place the residue in a tube for organic analysis, and estimate the carbon according to the ordinary methods. It will therefore be well understood that the carbon found in a hundred parts of the substance only belongs to organic matters deprived of all fat.

The following are the gross results:—

First Series of Analyses.

No. 1.—The lip of a child of 8 years old in the healthy condition.

Water	49·23	
Fatty material	14·91	
Other organic material	35·86	of which 16·7 carbon
	100·00	

* It will be observed that these analyses bear both on dry and on moist gangrenes; the latter are not without interest, as a term of comparison.

No. 2.—The other lip of the same child affected with gangrene of the mouth; presenting a dry black slough on the surface, but forming a moist putrid mass in the deep parts—

Water	65·26	
Fatty material	17·00	
Other organic material	17·74	of which 8·45 carbon
	100·00	

No. 3.—Portion of the face of another child affected with commencing moist gangrene consecutive to variola—

Water	65·75	
Fatty material	9·54	
Other organic material	24·71	of which 12·23 carbon
	100·00	

Second Series of Analyses.

No. 4.—Toes and part of the metatarsus of the foot of a man aged 61 years, in healthy condition.

Water	53·18	
Fatty material	6·29	
Other organic matters.	40·53	of which 21·82 carbon
	100·00	

No. 5.—The same parts taken from an old man of the same age, who died at Bicêtre at an advanced period, although not yet complete, of a dry gangrene of the lower limb—

Water	37·26	
Fatty material	22·79	
Other organic matters .	39·95	of which 20·11 carbon
	100·00	

No. 6.—The same parts of a foot affected with dry gangrene as complete as possible—

Water	8·45	
Fatty material	23·80	
Other organic matters.	67·75	of which 33·51 carbon
	100·00	

The first result which strikes us in these analyses bears upon the quantity of water, very considerable in the case of moist gangrene, very slight in the case of dry gangrene. This result was foreseen; but it is remarkable that in moist gangrene the quantity of absolute water is much greater than it is in the healthy state; there has been, therefore, not only absence of evaporation, but production of new quantities of liquid.

It is not less worthy of attention that this excess of water corresponds to an important diminution of the organic materials, the sum total of which descends from 50·77, the normal standard, to 34·74 in one case, and to 34·25 in the second case. The excess of water, about 16, is precisely equal to the diminution of the organic materials, which renders it very probable that the water has been formed at the expense of the latter. Let us add that these two pieces exhaled an infective odour, and that there was disengaged a certain quantity of volatile substances—ammonia, sulphuretted hydrogen, carburetted hydrogen, &c.

In the second series the absolute quantity of the organic materials (fat and albuminoids) has notably increased in per centage. But we must take account of the diminution of the water.

Now, excluding the water, let us see the relation of the quantity of fat to that of the other organic matters. This relation is expressed by the following standards:—

No. 1.	Healthy lip	0·415
„ 2.	Diseased lips	0·950
„ 3.		0·386
„ 4.	Healthy foot	0·155
„ 5.	Diseased feet	0·570
„ 6.		0·351

Thus the quantity of fat, compared with that of the albuminoids, slightly diminished in a case of commencing moist gangrene (No. 3). This case ought to be considered as anomalous; because in all the others this quantity considerably increased, in one case even (No. 2) we see the relation expressed by a standard approaching unity. Thus the fact resulting from the microscopic examination is found confirmed. Gangrene, and especially dry gangrene, is accompanied by a very notable increase of fat. It is interesting to know the quantity of carbon existing

in 100 parts of organic matters previously deprived of water and of fat. The accuracy of the figures which follow is guaranteed to me by their approximate agreement with those which result from the best analyses of the principal nitrogenous substances. The mean quantity of carbon contained in fibrine, caseine, and albumen is 53·26 per cent.* These are the figures:—

No. 1	46·57	of carbon per cent.
„ 2	47·63	
„ 3	49·49	
„ 4	53·83	
„ 5	50·34	
„ 6	49·16	

Thus, in the cases of moist gangrene there is an increase of the carbon of the nitrogenous materials, and diminution in the cases of dry gangrene.

But let us not lose sight of the increase of fatty matter which is the rule. The preceding facts enable us to investigate the absolute quantity of carbon which exists in 100 parts of the tissue (everything included). For this, it is sufficient to recall that, according to M. Chevreul, human fat contains 79 per cent. of carbon. We can therefore from each estimation of fat ascertain the absolute quantity of carbon which enters into its composition, and add this quantity to that of the carbon of the proteid materials given directly by analysis.

Working in this way we find the following figures:—

No. 1	28·47	of carbon
„ 2	21·88	„
„ 3	19·76	„
„ 4	26·79	„
„ 5	52·31	„
„ 6.	38·11	„

It results from this calculation that the absolute amount of carbon has diminished in the case of moist gangrene, and increased in that of dry gangrene.

Whatever may be the cause of these differences, the only point which it is important to retain is this: in dry gangrene there is a slight diminution of the carbon of the nitrogenised materials; but this diminution is more than compensated by a considerable increase of the quantity of carbon which exists in a given region, and this increase is itself allied to the se of fatty material. Whence proceeds this increase of fat?

* *Vide* Malaguti, *op. cit.*, T. ii., p. 49.

In a general way we may say that since the very active combustions have for their known result the expenditure of fat, it is not surprising that in a very slow combustion it should accumulate. But this does not suffice. This principle cannot have been brought ready formed by the arterial blood (the arteries being obliterated in the cases which I have cited); one is therefore compelled to believe that it is formed *in situ* at the expense of the nitrogenous materials. This transformation of albuminoids into fat may be now considered, if not an actually demonstrated fact, at least one in process of demonstration. I cannot state here all the reasons which militate in favour of this view, which has been keenly discussed by chemists during the last few years. I will content myself by recalling that it is definitely maintained by M. Boussingault*; that Lehmann† is strongly inclined to support it; that according to the experiments of MM. Wagner and Husson on introducing into the ventral cavity of a goose or of a pigeon crystalline lenses of the pig, the calf, or of the human subject, of which the quantity of fat has been previously determined, it is found that after a certain time of sojourn this quantity has notably increased; this transformation has even been obtained with cooked albumen.‡ The general cause of the phenomenon would appear to be an incomplete combustion, and it is considerations of this kind which have led Liebig to conclude that in the physiological state the production of fat in animals is the consequence of a disproportion between the quantity of the aliments consumed and the quantity of oxygen absorbed by the skin and the lung.

IX. Let us seek now to give a theory for the gross facts of experience whilst stating precisely what takes place in dry gangrene.

Let us take, for example, a slough produced by a burn of the sixth degree. It is not pure carbon, but a material which in composition closely approaches it. What then has taken place? Under the influence of heat there has been a combination of the hydrogen of the living tissues with the oxygen of the air, and also with that of the organs, to form water which is disengaged

* *Economie rurale*, 2nd Edit., T. ii., p. 617.

† *Précis de Chimie physiologique trad. Drion.*, p. 311.

‡ "Comptés rendus de l'Académie de Médecine de Belgique." *Gazette médicale*, 1858, p. 504.

as vapour. The combinations of nitrogen may be neglected on account of the very small quantity of this element. The result is the setting free the carbon, and this results simply from the hydrogen having more affinity for oxygen than carbon. The heat which suffices to carbonise a limb does not suffice to make carbon pass into the condition of carbonic acid; but this is what would happen infallibly at a more elevated temperature, and finally there would remain nothing more than a morsel of inorganic ash.

Let us take a second example, viz., the slough formed by sulphuric acid, which perhaps of all forms most resembles by its aspect the sloughs of spontaneous gangrene. What happens in this case? Sulphuric acid having an immense affinity for water, the oxygen and hydrogen of the tissues combine together to form the molecule water which becomes absorbed by the acid and carbon is then set free.

Now let us suppose that there is an arterial obliteration. From the chemical point of view two important modifications result: absence of water, absence of free oxygen. The remainder may be neglected. Doubtless it will appear paradoxical to take for a type the slough produced by a cautery, actual or potential, which slough one commonly attributes to an exaggerated combustion, and to place over against it the excess of carbon produced by a diminution of oxygen or, what comes to the same thing, by a slow combustion. Nevertheless we shall see that they are almost identical.

An important fact dominates the history of spontaneous gangrene, it is that everything does not die at the same time. At first it is infinitely rare for the arterial blood supply to be absolutely suppressed all at once; in the second place, when even this suppression is complete, the action of the veins continues. Thus on the one side the venous radicles still absorbing liquid, and the arteries no longer bringing new quantities, there is present one cause of very rapid desiccation to which evaporation comes to be added; and on the other hand, thanks to the persistence of the return circulation, the interstitial combustions, although considerably slowed, continue to be effected in the intimate structure of the tissues. Hydrogen by virtue of its affinity with oxygen unites with that element to form a certain quantity of water, whilst the more difficult combustion of carbon

becomes more and more incomplete; moreover the rapidity of the drying up is opposed to the putrid fermentation. To these phenomena of a purely chemical character we must probably add a vital phenomenon, viz., that resistance to the causes of destruction, of which the living organism each moment gives us a proof, and in virtue of which a normal function when it is accidentally hindered is supplemented by an accessory function. We all know, for example, that in the case of an animal, if we diminish the amount of fatty food of which it has need for its nutrition, it will supply itself by burning up what it holds in reserve.

By an analogous mechanism, when an arterial obliteration has diminished, if I may so speak, the supply of oxygen to which the organs are habituated, the combustions are not thereby annihilated; they continue as long as possible, and in order to satisfy them the living tissues consume their own oxygen.

Hydrogen is first burnt, a little carbonic acid is formed, and that is the cause of the slight diminution in the proportion of the albuminoid materials.

The final result is a tendency more and more marked to the setting free of carbon.*

Such is the phenomenon considered as a whole. But the formation of water and that of carbonic acid are not the ultimate products; it is certain that in reality these transformations are made by a series of intermediate compounds. "The nitrogenised materials," says M. Longet,† "do not come from all sides to offer themselves to the atmospheric oxygen introduced by the respiratory organ, but they are probably split up into a carbonaceous material which is consumed in respiration, and into a specially nitrogenised material which passes away by the urinary excretion." In the case which now occupies our attention it seems to me rational to admit that one of the first terms of the reducing action which is exercised upon the albuminoid materials, or if one prefers, one of the first effects of the splitting up, is the formation of that rose colouring matter which I have previously mentioned, and which one could not

* It is needless to add that I take no account of the nitrogen which enters doubtless into the intermediate products.

† *Traité de physiol.*, T. i., p. 1037.

liken to anything better than the Chinese rose colour, obtained by acting with hydrochloric acid in the cold on a solution of albumen.

One degree further, a more complete splitting up would correspond to the formation of fat, a ternary compound, and this would not be the last of the series.

It is possible that hæmotosine may be the seat of analogous phenomena, and that the deeper and deeper colour which it takes up to the formation of the gangrenous corpuscle of Valentin may only be the index of a carbonisation more and more advanced. But this is only hypothetical.

The very low temperature of the gangrenous limbs does not contradict the existence of chemical changes taking place in their substance.

The slowness even of the combustions is a primary cause of chilling. We must add (1) the absence of the hot permanent injection which corresponds with the entrance of the arterial blood, (2) the evaporation. This cause by itself alone is adequate to explain a notable lowering of temperature.

Dupuytren has been much criticised for the assertion that the temperature of gangrenous limbs sinks below that of the surrounding medium; the statement is not so diametrically opposed to physical laws as it has been represented.

X. Analogies are not wanting in support of the theory of gangrene which I have just proposed.

The common phenomenon of the combustion of a lamp may serve here for useful instruction.

The oil and the match considered together may be thus formulated: water, plus carbon, and an excess of hydrogen. The water vaporises, all the hydrogen is combined with the oxygen of the air; as to the carbon, it passes into the condition of carbonic oxide and carbonic acid in the points where combustion is most active; but in the centre of the flame carbon is reduced, and it may be collected upon a cool body in the condition of lamp-black. Carbonisation in a closed vessel rests on the same principle. This is what takes place under the influence of heat and in contact with the atmosphere. Now the same process may go on for a long period in the interior of the earth, and it is that lignites and coals are formed.

:e is produced at first a series of tarry matters of which

the composition is not without analogy with that of fats, and from which on final analysis carbon is set free. Here we have to do with one of those phenomena which the beautiful researches of M. Berthelot have brought to light during late years; bodies obey their natural affinities, only the element of time replaces that of heat, and the carbon which is formed by super-oxidation in free air and under the influence of caloric may be formed also without heat and without air, wood burning at its own expense. It is remarkable that in regard to cellulose and sugar the dark coloration becomes more pronounced in proportion as the composition of their derivatives approaches pure carbon.

Starting from cellulose we have successively carramel, ulmic acid, humic acid, &c., which are darker and darker. It is possible that the same may obtain with the azotised matters.

But as nothing is more variable than the phenomena of coloration we can affirm nothing absolutely in that matter; and however this may be, there is no need of this explanation, as we have already seen, to give an account of the colour of gangrenous tissues.

To conclude, and in spite of the immense lacunæ which the actual state of science does not allow us to fill up, the intimate phenomena of gangrene, which up to now have never, so to speak, been studied, appear to me of the highest importance from the physiological point of view. They represent to us, if I may so speak, nutrition taken in the act and even analysing itself. Normal nutrition passing to the confines of the arterial and venous systems escapes from all study by its complexity, and it is impossible to say how much belongs to one of these systems and what depends on the other. Perhaps in following the way which I have here indicated, in considering gangrene as the suppression of half of the circulation with preservation of the other half, it would be possible to arrive at some more rigorous results on the mechanism which presides over the maintenance of local life and over the phenomena of assimilation.

This leads me by a natural transition to the subject which I shall approach in the following chapter. If, as I have attempted to prove, the fundamental fact of gangrene consists in the diminution or the absence of oxygen necessary to the integrity of the life of a tissue, the pathogenic conditions of gangrene considered

from a philosophic point of view will bring us back to the following cases:—

1st. Absence of blood dependent on all causes which may attack the normal functions of the arteries (obliteration of them is only a particular case). This condition can be compared to nothing better than syncope, in which the action of the heart is momentarily suspended. I propose to call it *local syncope.*

2nd. Presence of a venous blood, that is to say, of a blood insufficiently oxygenated. Continuing to use a term of comparison in the same order of ideas, I will designate this condition *local asphyxia.* I do not invent this word, already employed by many authors; but I seek to give it a precise meaning.

3rd. It is possible that in consequence of an intoxication inexplicable as to its nature the living cell, although having at its disposal the elements destined for its nutrition, may be struck with powerlessness to profit by them. This is possible, although not demonstrated; but we must admit that it may be possible. I do not believe that we can *imagine* a fourth hypothesis.

CHAPTER II.

CASES.

Before narrating the cases which will serve for the basis of this memoir, I ought to say one word on the circumstances which led me to collect them.

It was in the beginning of 1860 that one of the cases subsequently reported (Case XV.) strongly attracted my attention.

The case was one of spontaneous gangrene of the four extremities, which had occurred unexpectedly in a young woman aged 27 years. During nearly a month I saw a series of strange and formidable phenomena unroll themselves under my eyes and disconcert the vast experience of many eminent physicians who saw this patient with me. In vain all the organs were minutely explored; in vain all the causes, known or probable, of gangrene were sought. It was necessary to admit the intervention of some influence up to that time ignored. I put myself in quest of similar facts, and once forewarned of their possibility I soon met with them. All appeared to me to present as a common character the absence of a material appreciable obstacle to the course of the blood, whether arterial or venous. That which I had seen it was impossible but that others should have seen before me. In going through medical literature from this point of view I have found a certain number of precious documents. Thus I have obtained a record of 25 cases, of which 5 are my own.

I am far from attributing the same value to all these facts.

Some of them are incomplete, some are doubtful, and would appear at first contradictory to the conclusions which I profess to draw. There was a very simple means of avoiding this inconvenience, viz., to gather together all the facts which were sufficiently obvious, and which could admit of neither difficulty nor controversy, and to suppress the rest. There still remained ample evidence to give the elements of a sufficient conviction on the subject. But on the one hand it was incumbent on me to show that a symptomatology more or less analogous to

mine had already struck several observers, and on the other hand I was anxious not to incur the reproach of having selected facts which were favourable to my view, whilst deliberately omitting those which were unfavourable to it.

Presented thus, the observations may give rise perhaps to some doubts, but I should lie if I said that there were none left in my own mind.

Whatever the interpretation may be, there is interest in gathering into one group this series of cases previously scattered through literature, and the facts themselves will remain. I had perhaps to treat of a question which had already been prejudged, viz., that of the possibility of a gangrene without obliteration. I have already foreshadowed my views, and I refer now to M. Zambaco's thesis on the subject, which contains many conclusive proofs that such a form of gangrene is possible. Moreover I believe that all the facts subsequently recorded in my work may be used as an argument in support of this opinion, and that thus they have a double use.

The order in which I have ranged these observations is not indifferent. I consider syncope and local asphyxia as the first indication of a state much more grave, characterised by a cooling carried to the extreme, by the formation of an eschar, and the fall of many parts of the phalanges of the hands and the feet. We arrive thus by degrees at the case which has served me as a type. It has seemed to me nevertheless that this degree could indeed not be itself the last of all. Also I have placed at the end a certain number of cases in which without known cause many segments of limbs have become detached by gangrene.

I could easily have collected others; but as the greater part are of ancient date I should have been wanting in respect to the rules of a healthy criticism in accepting records which were somewhat indefinite, and which were not always sufficiently authenticated.

I have therefore only admitted those which have appeared to me to present striking analogies with my typical observations.

Thus these facts, of which many were known and quoted only as anomalies, acquire, when viewed alongside of those which precede them, a value which they did not previously possess. Between the simplest cases, and I would say even the most [illegible]n, and those which are most astonishing from their

gravity, there are only differences of degree and intensity. The important thing is to find the intermediate cases.

1. *Syncope and Local Asphyxia in their Simplest Form.*

The most simple degree is a state which every one knows, although it is not, so far as I am aware, described in any treatise on pathology. It corresponds to that which in common language is spoken of as the *dead finger*. This affection, which constitutes hardly even an inconvenience, and which passes often unperceived because it claims no treatment, is nevertheless very common, and there is hardly a doctor who has not had many opportunities of observing it. The following is an example which has no other interest except that it faithfully summarises what takes place in the majority of cases of the kind.

Case I.—*Local Syncope of the most Simple Form.*

Mme X., æt. 26 years, has never been ill; but she has been the subject since childhood of an infirmity which makes her an object of curiosity to her acquaintances.

Under the influence of a very moderate cold, and even at the height of summer, she sees her fingers become ex-sanguine, completely insensible, and of a whitish yellow colour. This phenomenon happens often without reason, lasts a variable time, and terminates by a period of very painful reaction, during which the circulation is re-established little by little and recurs to the normal state.

Mme X. has no better remedy than shaking her hands strongly, or soaking them in lukewarm water. The index of the left hand presents a susceptibility greater than all the other fingers, and is often affected alone. The feet, more impressionable even than the hands, are regularly attacked at meal times and whilst digestion is going on.

Menstruation does not appear to have any influence upon the appearance of the phenomenon, but it is a remarkable fact that the complete disappearance of attacks of local syncope has always been noted by this lady as the first index of a commencing pregnancy.

If the distinction which I have drawn be accepted, this state, which I dare hardly call a disease, is local syncope in its simplest form.

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COOPER
and is not to be taken away

It is to be noted that we have here not a passive congestion, but rather a momentary absence of local circulation, just as syncope is a suspension of the general circulation.

When this state is repeated up to the point of becoming almost continuous, it may at length lead to profound troubles in the nutrition of the parts which are subject to it. Chilblains become to some extent established, and the adipose tissue ultimately becomes over-developed, as in all organs which perform their functions incompletely. This is what took place in the following case.

CASE II.*—*Habitual Local Syncope with Lesions of Nutrition.*

X., 25 years, a young lady of small build, and of a very clear, light complexion; menstruation faulty during many years, but regular since 24; slightly icteric; has had several attacks of "nerves," with loss of consciousness, globus, tears, and involuntary laughter.

From the age of 14 to 18 years she suffered much from chilblains, which kept her laid up during three months of the winter. She has for a long time suffered from dead fingers. These were constantly becoming absolutely cold, pallid, and insensitive. The return of the catamenia has not modified this condition.

The fingers present a conformation which is quite remarkable—they are extremely gross and soft; the hands themselves seem œdematous, and this contrasts in a striking manner with the wrists and very slender forearms. The nails are not clubbed. The pulse is quite perceptible. The feet present the same appearance as the hands; they seem as though they were made up entirely of skin and cellulo-adipose tissue. This young woman died recently of a hydatid cyst of the liver.

Up to this point we have had to do with slight forms of local syncope; it may acquire enough gravity to become disquieting. Everybody knows the curious fact recounted by Lamotte (*Traité Complet de Chirurgie*, 3rd Edit., T. ii., p. 317).

A billiard marker received a stroke from a stick on the outer part of his right arm. There was severe pain, the hand became pale, cold, insensible; the morning after, Lamotte made many cuts with a lancet without the patient perceiving it; he even crossed the hand without a drop of blood escaping. This hand remained in the same state during ten days. At the end

* Communicated by Dr. Marey.

of this time a little heat returned, then the arterial pulsations, which had been suppressed, reappeared, and the functions were so well re-established that the man could use his limb very cleverly at billiards. Now these phenomena, which in this case evidently had a traumatic cause, may in certain circumstances appear spontaneously. Volfius (Lib. iii., Obs. 5) reports a case in which a similar state appeared following a violent fit of passion, and lasting eight to ten days. The treatises of surgery contain many facts of this kind. The following, which I owe to the kindness of Dr. Blachez is not one of the least curious.

CASE. III.—*Local Intermittent Syncope simulating Paralysis.*

October 29, 1860, a young soldier was admitted into the Military Hospital of Gros Caillon for diarrhœa. He has always performed his duties well.

He gets out of breath rather easily. At the age of 16 years he had a malady which caused him to become swollen. This dropsy lasted seven weeks. He had never had any palpitations of the heart. The dropsy commenced at the feet and extended rapidly to all the body; he could not pass any urine for three days. After having consulted many doctors, he had recourse to a sorcerer, who cured him in ten days by giving him powders of burnt broom mixed in milk, and by rubbing him with fat. Thirteen months afterwards he had typhoid fever at Marseilles. He made a good recovery. He has had diarrhœa twelve days before admission. No blood in the stools. He had lost his appetite, but continued at his duty. During the night before his entrance into the hospital he felt that his left arm was benumbed. For several days he had felt some ill-defined pains.

Actual state on the 3rd November.

In the morning the left forearm is completely algid; the radial pulse is almost imperceptible, the strokes of the brachial can be felt at the bend of the elbow. On the right the pulse is very feeble, 68—72. Nil cardiac. No feebleness of beats. Sensibility is blunted; the hand is slightly swollen and stiff; no ecchymoses; white patches on the forearm. The arm is of normal temperature; no pain, no swelling along the track of the vessels. The temperature of the right arm is a little lowered. There are a few white patches on it.

At eleven o'clock every day the heat and sensibility return.

It is to be noted that we have here not a passive congestion, but rather a momentary absence of local circulation, just as syncope is a suspension of the general circulation.

When this state is repeated up to the point of becoming almost continuous, it may at length lead to profound troubles in the nutrition of the parts which are subject to it. Chilblains become to some extent established, and the adipose tissue ultimately becomes over-developed, as in all organs which perform their functions incompletely. This is what took place in the following case.

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November 8.—In the morning, symptoms just as described. About one o'clock at night he was wakened by prickings and a sensation of numbness; then the right forearm became cooled; absence of radial pulse, analgesia, &c. At half-past twelve (noon) the heat of skin returned and became even exaggerated; pulse 68. The left radial pulse is found to be always more feeble than the right. The hand is slightly swollen, so that it is difficult for him to bend his fingers. There is analgesia distributed in the following manner: all the forearm and the hand are analgesic, but it is especially in the external third (ring finger and little finger) that it is pronounced. The patient feels when he is pricked rather strongly; he cannot squeeze the hand nor move the forearm; on pressure he complains of pain, or rather of exaggerated sensibility, along the median line of the forearm in front. There is a little headache, inappetency, white tongue; no spots on the belly. He rises in the afternoon. 0·4 grm. of sulphate of quinine ordered.

November 9, morning.—Arm hot; pulsations feeble, a little more so than on the right side; analgesia and amyosthenia as before. Less pain and tingling; the patient can seize nothing, nor can he squeeze. Sulphate of quinine 0·4 grm.

November 10.—One feels the left radial less strongly; cooling less than before, most pronounced in the dorsal region; analgesia and paralysis more pronounced; diarrhœa continues. Sulphate of quinine 0·4. grm.

November 11.—Forearm less cold than the day before; the pulse is felt very feebly; the algidity goes up the posterior surface of the arm; the right arm is a little cooler than in the normal state. Sulphate of quinine not given this morning.

November 15.—Arm always colder and pulse smaller on left than on right side, but there are no more intermittent phenomena; a little œdema of the hand. Diarrhœa arrested for two days.

November 21.—Same state, save that the œdema is more pronounced; anæmia; appetite well preserved. Sulphur douche ordered.

November 26.—He has had the douche for a few days. The algidity has reappeared and persists throughout the day; the arterial pulsation is only felt at the bend of the elbow; the same signs as before. On electric examination sensibility and contractility much less developed on the left than on the right

side; the inequality is even marked on the sides of the chest; the skin reddens on application of electricity. After a sufficiently prolonged application there was no change in the temperature nor in the pulsations.

November 29.—At the end of an application lasting for ten minutes the patient was taken with an attack of hysteria, tears, cries of despair; no loss of consciousness; contraction of the fingers, not only of the electrified side, but also of the other; very violent pains in the arms; nil in legs. The attack lasted one hour. Nothing special followed.

The patient went away for the waters, not cured.

This case presents more than one remarkable circumstance. The functional lesion which produced the local syncope extended upwards from the capillaries to the arteries. Nevertheless an obliteration of the calibre of the artery by a clot could not be admitted; the proof is that the circulation was interrupted, but reappeared soon after, then was interrupted again—and still more curious—this interruption took on the intermittent type. Sulphate of quinine modified this condition, destroyed the intermittence without curing the malady entirely. Further, this man suffered from a hysterical attack which was quite characteristic. This occurrence rare, although not without precedent, in the male sex, denotes in every case a nervous predominance, and suggests for want of a better hypothesis, a spasmodic state of the radial and ulnar arteries.

Let us note that although the left upper limb was more affected than the right, yet the right was not exempt, and indeed presented an appreciable cooling of the surface. In that way the case comes within the general law of symmetry. I am, however, obliged to consider another case of local syncope limited to one side.

CASE IV.*—*Local Intermittent Syncope confined to one Limb.*

Some time ago I saw with M. Cusack a patient from the North of Ireland. She was a young lady of very delicate constitution, and who presented each day at a fixed hour very singular phenomena; the circulation seemed to become arrested completely in one of her legs, which became then completely pale and cold. This state persisted during ten or twelve hours,

* From Graves's *Lectures.*

then a new modification supervened. The leg became hot and painful, and this elevation of temperature was so painful for the patient that she was obliged to place her leg outside the bed clothes, and to sprinkle it constantly with cold water and vinegar. During all this time the pulsations of the heart were normal, and the circulation was natural in all the other parts of the body.

In the observations which are about to follow, the affection of the extremities changes a little in character. It is a state much allied to the preceding, but the cooling, the pain, the anæsthesia seem to proceed less from the absence of blood in the tissues than from the presence of blood which is unsuitable for the proper maintenance of sensation and nutrition. It is in one word local asphyxia properly so-called.

CASE V.—*Amenorrhœa, local asphyxia of the four extremities.*

Louise, a sempstress, aged 18 years, admitted April 2, 1860, to the Necker Hospital, St. Anne Ward, No. 21, under the care of M. Vernois.

This young woman had never had any other disease than an enteritis at the age of 7 years. She had begun to menstruate at the age of 15½ years without difficulty; the catamenia lasted eight days. She was not specially impressionable, and had never had any attack of "nerves." Her father died of cholera in 1854; her mother died phthisical October 27, 1857. During the last six weeks of her mother's life, whilst she was bathed with continual sweats, her daughter slept with her, saw her die, watched by her corpse, and received a vivid impression from it. A short time afterwards the catamenia were suppressed little by little; they have not reappeared for the last two years. About a month after the death of her mother, Louise saw the fingers of her two hands become yellow as though she had had jaundice. During a time which she cannot precisely give there were alternations of appearance and disappearance of this yellow tint of the fingers; cold provoked it, it disappeared in the warmth of the bed; it was accompanied with moderate pains; then the coloration became black, and the pains increased. Louise at that time followed the occupation of polishing plate, an employment which fatigued her fingers.

At the beginning of 1859 the feet became yellow, just as at first the hands had been affected. They remained yellow and

painful during about three hours. At the end of two or three months they gradually became black in their turn. In the month of July, 1859, she entered the Asile de la Providence, rue Oudinot, where they are occupied in washing linen every day. Her condition was continually getting worse. Whenever she placed her arms in water they became black, sometimes up to the insertion of the deltoids; she remedied this by placing them in the warmth of the bed, but at the moment of reaction she experienced a pain which she compared to that which nettles would produce, whilst during the continuance of the cyanotic tint it was rather a sensation of burning and shooting pains. Habitually, even in the intervals of the attacks, there was always a little pain, sometimes in one finger, sometimes in another.

Ordinarily when the cyanosis appeared without obvious cause it was limited to the fingers, and this happened not only on exposure to cold, but simply when the patient got up to go into the wards.

As the cyanosis increased there appeared a little tumefaction of the hands. On the feet the coloration rose as high as the ankle, but there was no swelling. The fingers are short, flattened, large at the ends, but not at all clubbed. There is at the heart a very slight blowing prolongation of the first sound. The patient takes cold easily. Nothing abnormal was to be heard on auscultation of the lungs. She has never remarked that there has been any monthly exacerbation.

On the 8th April, Easter Day, being at chapel, she was taken without assignable cause with pains in the hands sufficiently severe to make her cry; in the back she felt as though violently compressed by a vice. On the morning but one after (the 10th), whilst examining her as she lay in bed, I saw the commencement of an attack of cyanosis coming on without appreciable cause; the little finger was taken first, and the others soon afterwards became black in their turn. The patient quitted the hospital in the same state; tonics which had been lavished on her produced no improvement. The urine was examined, and gave only negative results.

I saw her again on the 12th December, 1861. I have not seen her subsequently. Her catamenia had appeared three or four times very irregularly, the last time a fortnight ago. The condition was sensibly improved. There were no palpitations;

the skin of the face presented a slightly bluish and transparent tint. I found her in the middle of an attack of cyanosis which had lasted for two hours; the pulse was quite perceptible; the skin of the hands was very cold, and of a violet tint.

The attacks recur now in the feet and in the hands five or six times a day without any periodicity; nevertheless in the moments of remission she can hold and handle a needle, which she could not do formerly; she does much work in the house. Good appetite; sometimes pains in the four extremities; nevertheless these pains do not attract her attention much, she has become habituated to them; she cannot say whether the improvement, of which she is conscious, has coincided with the return of the catamenia or not.

I call attention to the pale colour which the hands presented at first, and in like manner at a subsequent period the feet also, before they assumed the bluish black tint. This colour, much more pronounced than the pale yellow of anæmia, is not a fact without precedents. Already Broussais had drawn attention to the intense yellow tint which choleraic patients sometimes present whose limbs in their external aspect assuredly show a great resemblance to the state which we are now considering.

Furthermore, we see in this case in a very trenchant manner a remarkable coincidence between the affection of the extremities and suppression of the catamenial flux. I bring into contiguity with this case the following one, which is almost similar to it. I reproduce the title as it is given in the original; but it evidently describes very inadequately what the author wished to express.

CASE VI.*—*Cyanosis appearing instantaneously on parts exposed to the cold, ceasing under the influence of heat; re-establishment of the normal colour along the course of the arteries; no symptom of heart lesion.*

Rose G., washerwoman, aged 28 years, with fair skin and bright complexion, enjoyed habitually good health. Her pulse is small, feeble, and slow (65 to the minute). She has never had either palpitation, or oppression, or cough; she has never felt pains in the chest. She had always menstruated regularly up to the last three months, during which the catamenia had notably diminished.

* By Dr. Marchaud, *Journal des Connaissances médicales de Nantes*, 1837.

In the month of March she had several attacks of tertian fever, which disappeared under the influence of a sedative. Towards the middle of April she became very impressionable to cold.

Every time that she went out during weather at all cool, the nose, chin, cheeks, hands, and feet became pale; they passed then to a violet tint, then to a slaty white. It was in this state that she presented herself on the 20th April at the consultation at the Hôtel Dieu (at Nantes).

A very cold wind had blown all morning when Rose entered the room. Her cheeks and chin were of indigo colour; her hands were as cold as marble. At the first view I believed them to be gangrenous. The ends of the fingers were of a greenish blue, the palms of the hands were of a deep purple. On the forearms there were marblings similar to those which are present on the legs of persons who use foot warmers. Above the wrists the skin presented its natural colour. These phenomena were less pronounced in the lower limbs, which were clothed with woollen stockings.

Whilst this young woman spoke, a bright redness began to develop itself at the root of the nose and over the cheeks; then it extended and invaded the blue colour, which soon formed no more than a deep red patch on the tip of the nose, and ended by disappearing entirely. One moment afterwards the pink colour of the nose began to pale, and this organ resumed little by little its ordinary colour. The same change came into operation at the same time upon the cheeks and the chin; upon the hands the change did not take place so quickly nor in the same way.

The pulse was small, feeble, thready, disappearing easily under pressure, especially in the left arm.

The right radial was a little more developed than the left, and the pulsation was always stronger and more prompt in the right than in the left. This was how the change took place: at first less livid patches appeared in the palms of the hands along the track of the palmar arches; they extended until their borders met, and took on a vermilion tint. At the same time other patches were seen to form along the course of the digital arteries, and shoot along the collaterals of the digits.

It was at the extremities of the fingers that the cyanosis and the cold persisted longest. Finally at the end of a quarter or half an hour the whole hand was of a vermilion red; the pulse

had regained its force, the warmth of skin was perfectly developed, and a slight sweat had moistened the cutaneous surface. All these phenomena were reproduced each time that Rose was exposed to cool air, whether in the evening, morning, or at the middle of the day. The reaction only commenced when she returned to her room.

One day when the outside temperature was at 54½° F. the thermometer placed between her fingers only rose half a degree, and stopped at 56¾° F. in the palm of the hand. This experiment repeated two days running always showed that the thermometer placed in the palm of the hand only rose one degree above the temperature of the air, and half a degree only when it was placed between the digits. The means which were employed during the sojourn of the patient at the Hôtel Dieu from the 2nd May to the 21st of the same month were as follows: frictions were prescribed with camphorated brandy and laudanum over all the parts which reddened. During two or three days we administered also two grains of sulphate of quinine; then the patient complaining of pains in the stomach the sulphate of quinine had to be omitted, and it was replaced by a grain of extract of opium, given night and morning. Constipation occurring at the end of a few days we were obliged to give up the opium and recur to purgatives.

These different remedies produced no manifest improvement, but during their employment the external temperature rising the cyanosis became less and less marked, and no longer appeared when the atmosphere became warm.

CASE VII.*—*Local Asphyxia: beneficial employment of electricity.*

A young woman, aged 17 years, experienced without appreciable cause violent pains in the hands, which appeared of a dark slaty colour; there was cooling of the skin, and insensibility, in short all the symptoms of a commencing gangrene occupying four the right and two on the left hand. Power of move- gers was almost abolished. We employed the Its application was at first very painful, but he pains which the patient experienced spon-

ical Suisse, Sep., 1858. This observation bears improperly ngrene of the Fingers."

taneously. Ten or twelve applications brought back at the end of about a week, sensibility, normal colour, and temperature, as well as power of movement. The epidermis detached itself from the two hands over the whole of the extent primarily occupied by the commencing gangrene. There was remarked during electrisation a very curious fact; there was a fœtid sweat over the area of the electrified parts.

This patient succumbed a few weeks later to acute phthisis, but no autopsy was made.

II.—*Local asphyxia and superficial gangrene, with predominance of the nervous element.*

I pass now to an order of facts in which the nervous element takes a principal part, and conceals in part the influence—nevertheless very real—of the circulatory troubles.

I will record first a very interesting observation of Dr. Landry's, who has already published an abstract of it in his remarkable researches on the causes and curative indications of nervous maladies. I restore it here in its entirety, as it has been kindly communicated to me by the author.

Case VIII.—*Chlorosis, Hysteria; remarkable symptoms on the side of organic phenomena and of sensibility.*

T. (Adolphine), wife of R., aged 22 years, a daily worker at the Beaujon Hospital. Admitted April 5, 1851, under the care of M. Sandras.

Constitution of debilitated appearance, nervous temperament. Her parents are still living, and have never experienced anything analogous to her actual state. Sickly up to 12 years old, convulsions in infancy, variola, measles, &c.; began to menstruate at 14 years. At the end of a year the catamenia were irregular for a short time, but then became regular again, and each month the loss of blood was very abundant, and lasted eight days. When the menstrual troubles first appeared (that is, one year after the commencement of the catamenia) there occurred simultaneously several different symptoms: pains in the stomach, frequent breathlessness, and a subfebrile state without cough or palpitations. After recovering from these symptoms her health was good until she was 21 years old. At this epoch she had a satisfactory labour, but it was followed by abscess

of the breast and by a tertian intermittent fever, which lasted three months. A fortnight after its disappearance there was a sharp pain in the left foot, exaggerated by walking, and indeed preventing it. This pain had for its seat the tibio-tarsal articulation, and was not accompanied either by redness, or sensible tumefaction, or by fever. It came to an end of itself at the end of a fortnight. Shortly afterwards the left arm became the seat of severe pains, like those due to bruises, especially severe about the articulations, and rendering movements impossible, or at least difficult. There was no redness, tumefaction, fever, or general trouble. This pain finally disappeared at the end of two months. From that time the health was very good up to November, 1850, but for a few palpitations and attacks of breathlessness.

At this epoch this woman experienced suddenly a considerable feeling of cold at the end of her fingers, without having been exposed to a low temperature. The nails became violet, and the ends of the fingers a sombre red, and they were the seat of a sharp pain, compared by the patient to that of benumbing by cold. These symptoms continued; they were especially sharp in the morning, disappeared during the day, then in the evening and during the night the painful cold was replaced by a burning and intolerable heat. During these periods cold water calmed the sufferings, but on the contrary excited them in the cold period. These symptoms gained gradually in intensity, and at the end of a fortnight the cold became permanent, and the extremities of the fingers took a tint of deep violet red, passing into black at certain points. The pain similarly became much more severe, and the least contact excited atrocious pains and determined convulsions. All these symptoms were especially acute on the left side. M. Robert, on being consulted, believed at first that there would supervene one or many whitlows; but after a more attentive examination he concluded that there existed an alteration of the arteries (arteritis), and ordered forty-four leeches to be applied to the palm of the hand and over the ends of the fingers three times over, then laudanum poultices and ethereal draughts. The symptoms were calmed without being cured. At the same epoch the extremity of the nose took a violet tint like the ends of the fingers, and each morning some drops of blood escaped from the nostrils; otherwise there was no pain.

She left M. Robert's ward after three weeks' stay. A fortnight afterwards there was increase of pains with frequent convulsions, for which they were obliged to tie down the patient. She was admitted under the care of M. Huguier, and laudanum was applied over the ends of the fingers. M. Huguier considered these attacks as symptomatic of an affection of the heart, and this opinion was based upon the existence of violent palpitations and of a cardiac murmur, perhaps also upon the knowledge of the antecedent articular pains of which I have spoken.

In the space of a fortnight he ordered wet cupping five times, then blisters and cauterisations to be applied over the præcordial region, and digitalis to be given internally. The sum total of this medication appeared to improve the pains without leading to any change in the other conditions of the fingers, and without modifying in any way the palpitations and the cardiac murmur. At the end of January, 1851, the pinna of the right ear took the same tint as the fingers and became the seat of pain and tingling, which disappeared at the same time as the cyanosis, in the course of the month of March. The patient passed from the care of M. Huguier at the end of the same month. The pains of the fingers and the convulsions appeared once more, and she came under M. Sandras' care on the 5th April, when we noted the following condition: general state is good, but there are frequent vertigoes, hummings in the ear, palpitations, attacks of breathlessness, constipation, with no other abnormality of the digestive system; pulse small, very compressible, but quite perceptible in both radials; with the first sound of the heart a murmur, having its maximum intensity at the base, but most intense over the aorta and the carotids; murmur only slightly harsh, and by no means in harmony with the view of organic affection held by M. Huguier. The extremities of the fingers of the two hands present a violet colour, which is seen also under the nails, and occupies almost the whole of the extremity of each finger, but decreases from the extremity towards the hand. This colour, more marked in the right hand than in the left, extends a little further along the internal border of the fingers than in any other direction, and is prolonged along the internal border of the little finger up to the inner side of the hand and the inferior third of the forearm. The extremities of the fingers are very cold, shrivelled, and withered; even a moderate pressure

determines in it a sharp pain; nevertheless a superficial prick of a pin is not perceived at all, but it is felt with pain if one drives it in deeply; tactile sensibility is lost at the ends of the fingers, and the patient does not feel a pin roll between them. For this reason it is impossible for her to pick up small bodies, and not appreciating the volume of them she does not appreciate the degree of pressure which she ought to exercise upon them in order to retain them and lets them fall; the tactile sensibility is not otherwise altered except upon the distal phalanx, and principally at its extremity. The epidermis of the end of the digits peels off gradually and in small patches; the skin itself is thin, dry, parchment-like, and shrivelled. The extremities of the fingers are the seat of a pain compared by the patient to that of being benumbed, with torpor and the sensation of intense cold, cold moreover which is very real and quite appreciable to the touch of the observer. The pain radiates from these points up to the shoulder without taking any particular direction in relation to the track of any vessel or nerve. The patient in spite of this sensation of cold and numbness seeks cold rather than heat. The warmth of a fireside nevertheless does not sensibly increase the pains; but when the hands have remained for a certain time in the heat of a bed the sufferings are increased, then alleviated by exposure to cold air. Sometimes these pains take on an extreme intensity and radiate more violently, but with a different character, towards the shoulder; then the least contact renders them atrocious and determines violent convulsions, such as one observes in the most disorderly attacks of hysteria; nevertheless they are not accompanied by a sensation of globus, so common in hysteria, and they show no epileptic character. This state of exaggeration of pains comes back in attacks of about one hour's duration, being renewed five or six times daily; each of them is marked by three or four attacks of convulsions; otherwise there is nothing constant in their manifestations. During these attacks the extremities of the fingers take a violet colour, and at the same time become warm; at other moments, and especially during the periods of remission of the pains, the fingers become a dead white in colour and absolutely exsanguine.

All these phenomena are much less marked in the left than in

the right. On the right side the index finger presents none of these phenomena (it is not cyanosed, or cold, or shrivelled; the sensations perceived in the other fingers are not present in this; sensibility in it, is perfectly preserved). They are on the contrary at their maximum of intensity on the middle finger of the right hand. We have specially noted the following fact. During the attacks chloroform was applied over the digits of the right hand. The pains were calmed, but the tingling which this liquid determined was only felt by the index; and upon this finger only, a blister was formed round the nail. This blister was evidently the result of vesication determined by chloroform when the application had been too long prolonged.

The right ear showed nothing like what it presented before. The end of the nose was slightly violet and cold, without pain.

On the toes there was nothing similar to what was seen on the fingers. There was no other lesion and no other alteration of sensibility in any part of the body; there was no pain over any of the spinous processes.

The history of the symptoms which I have just enumerated was taken on the 13th April, that is to say, eight days after the admission of the patient; and after having observed her during that period she was ordered gelatine baths daily, and carbonate of iron pills, four daily. When the attacks occurred compresses soaked in water and chloroform were applied over the fingers. These instantly quieted the pains, and since then she has had no further attacks.

April 27.—There has been a sensible improvement in all the phenomena. Nevertheless to-day the cyanosis is extended by patches up to the dorsal surface of the hand. The radial pulse has always been normal on the two sides, or rather has been characteristic of the chlorotic state of the patient, that is to say, small and compressible. We have remarked nothing special with regard to the veins. The heart murmur is moreover almost nil, and the palpitations only slight. The same treatment to be continued.

May 4.—The pains and other symptoms have much diminished in the right hand, but have acquired more intensity in the left. There was yesterday an attack of convulsions determined by pains in the left hand; there had been no convulsion since

April 9th. The same prescription, and in addition a julep was ordered with 30 grammes of syrup of morphine.

May 15.—The symptoms, and especially the pain, are almost nil in the right hand, but sufficiently intense on the left side to have determined yesterday morning another attack of convulsions. The pain in the left hand exists especially in the three digits, the thumb, index, and middle finger. General state very good. The use of the gelatine baths is continued, but every three or four days only, and the use of the chloroform compresses is continued. The same prescription as before.

May 18.—The patient remarked to me that for several days the cold and cyanosed extremities of the left hand have been the seat of continual cold sweating, and that it is reproduced just as one dries it. This perspiration recalls that of choleraic patients.

May 21.—The symptoms are very intense in the left hand. M. Sandras ordered cold irrigations to the ends of the fingers. Same prescription.

May 23.—The irrigations quieted the pains considerably, but the patient having suspended them the pains have suddenly increased with great intensity. There has been a violent attack of convulsions. The irrigations to be continued. The same treatment.

May 25.—This morning the fingers of the left hand have almost returned to their normal colour, and their extremities hardly present any violet tint. They are equally without pain, and pressure only determines it on the index. The irrigations have been continued since the 23rd of May without interruption. The same treatment.

June 15.—The irrigations have been continued, but their good effect has not persisted, and the patient is better for the chloroform applications, which instantly quiet the pains and make the fingers assume a dead white colour. The right hand is always in very good condition, and since the symptoms have disappeared the skin of the extremities of the fingers has regained its normal appearance, and the desquamation which was noted previously has disappeared. Desquamation and parchment-like atrophy of the skin are still observed on the fingers of the left hand. The irrigations were suspended. The same prescription to be continued.

June 17.—Since the suspension of the irrigations the pains have reappeared more violently, and we have been obliged to return to them.

June 19.—The irrigations have diminished the pains. M. Sandras ordered inunctions with an ointment containing lard 60 grammes, sulphate of strychnia 1 gramme; otherwise the same prescription.

June 25.—Since the patient has made use of the strychnine ointment the left hand has been much better. The right hand appears as though it would be attacked again with the symptoms which had absolutely disappeared from it. The chlorosis is much improved.

July 10.—All symptoms had almost entirely disappeared from both hands; yesterday they reappeared with great intensity in both, but principally in the left. To-day this alone presented traces of the recrudescence of yesterday.

July 25.—There has been for a few days a considerable and persistent improvement in all the symptoms.

August 5.—The improvement has continued; nevertheless the cyanosis comes on at times as before; but contact is scarcely painful. The tactile sensibility is almost normal and the patient can sew very well, which she could not do on admission. There has been no further hysterical attack since May 23. The general condition is excellent, and the heart murmur and that of the carotids have disappeared; more palpitation. She goes out to-day, promising to continue the use of the carbonate of iron pills.

October 28.—This woman living at the hospital, I have had the opportunity of seeing her frequently. She continued Vallet's pills about a month after her dismissal, then ceased all treatment. Her general state continued very good, and indeed has improved. There have been no more convulsive attacks. The fingers, although still maintaining a violet tint and a temperature generally low, are no longer the seat of the old pains, and sensibility is almost normal. Every day their condition improves, and this patient may be considered as really cured, especially if we compare this long period of suspension of symptoms with the short intervals of improvement which she had obtained in a doubtful manner by the different courses of treatment which she underwent at first. She believed herself now pregnant one month.

February 3, 1852.—For many months the violet colour of the

fingers had disappeared, when after the death of her husband (Jan. 6) this woman had violent convulsions followed by nervous delirium. The fingers resumed temporarily their cyanotic tint, which however was not maintained. The delirium was cured in three days by simple draughts of syrup of narcotine in strong doses. Subsequently a very pronounced chlorotic state was noted with analgesia in almost the whole of the body, without anæsthesia. She is in our wards, where she is under treatment by Vallet's pills.

April 22.—The woman has not yet been delivered; she appears to be in the ninth month. Her general state is not improved. The analgesia and all the signs of chlorosis persist; there is a loud murmur at the base of the heart heard in the carotids; she has gastralgia, erratic pains, &c. For some time she has been frequently seized with complete aphonia, with absence of cough, pain in the neighbourhood of the larynx, expectoration, or trace of inflammation in the back of the throat. This often happens to her suddenly, and lasts some hours, or some days. No other nervous symptoms accompany this aphonia, and the patient pretends that it is from feebleness that she cannot speak, although there is nothing to indicate that her general feebleness is more marked at these times than at any other times; there have been no more convulsive attacks. The fingers have a tendency to become blue, but without pain. The Vallet's pills are to be continued, and also 2 grammes of magnesia at each meal. The patient's accouchement took place in June. For some time the analgesia had disappeared in part. After the labour there was considerable hæmorrhage. The patient is very pale and wasted. The analgesia reappeared everywhere. She left the hospital in June in order to go into the country.

October 11.—This woman returned from the country a few days ago, fresh, stout, and in excellent condition, showing none of the old nervous symptoms; no analgesia. Very slight palpitations; there is just a slight murmur with the first sound of the heart. She resumes her work as a hospital servant at the Beaujon.

November 7.—After having cleaned the metal vessels with potash, contraction occurred almost instantaneously of the fingers of the right hand, which are strongly flexed into the palm, the patient being unable to straighten them voluntarily.

November 8.—Pains in both hands, in the fingers, especially on the right side; pains very violent, similar in character to those formerly felt. Four attacks in the day, in which the fingers became blue in both hands, glazed, insensible to contact, and benumbed. Afterwards analgesia of the forearms and hands; murmur over the heart and the carotids.

November 9 and 10.—The same state, similar contractions; the same painful state, alternately blue and pale fingers, insensible and benumbed.

November 12.—Poisoning by about two spoonfuls of laudanum. Vomiting and coma, from which she was roused incompletely. The poisoning was not recognised.

November 13.—She has vomited some laudanum. Similar coma with incomplete resolution of the limbs; unconsciousness, pupils contracted. Coffea administered. In the evening tetanic rigidity of the lower limbs, incomplete movements of the upper limbs, insensibility, contracted pupils. Antimonial draught, coffea enema, two blisters to the calves.

November 14.—Consciousness perfect, movements almost complete; neither rigidity nor trismus. Analgesia almost general. She recalls nothing.

November 20.—Analgesia complete, numbness of the four extremities; toes and fingers very pale and very cold, insensible; more cyanosis of the fingers, altered movements of the lower limbs, almost complete paralysis of the muscles of the toes and of the peronei. The patient walks on the outer border of the foot, especially so on the right side. Gait trembling, frequent flexion of the knees. Slight contractility of the muscles to electricity, feebleness of hands, heart murmur. Four Vallet's pills ordered.

November 25.—Prolonged application of electricity.

November 27.—Marked improvement; walking easier; less numbness of the extremities, which are warm at present. Nothing more noteworthy. She goes to the Salpêtrière as a hospital servant. I have learnt subsequently that this woman died of phthisis. The autopsy revealed nothing special.

This case is extremely complex, and I do not flatter myself that I can disentangle all its obscurities, nevertheless it presents many special points which it is important to place in evidence. Although the malady affected the hands principally, it was not

absolutely limited to them. The first indication appeared in the left foot, at a later period the nose and the external ear were temporarily attacked, and in spite of their short duration these symptoms have a great value because they indicate a very general affection which we cannot explain by a lesion of heart or vessels. Moreover, these organs carefully examined, only furnished negative results. The progress of the symptoms was eminently chronic with exacerbations. During the space of two years six or seven of these attacks were observed and described; they had not all the same characters or the same duration, but they presented nevertheless general features which were well recognisable. There is a kind of prodromic period during which the morbid features are not yet definitely marked, and present an erratic character. But soon the malady finally leaves the lower limbs, and attacks the upper limbs with great severity in a more or less intermittent fashion. There is always a marked predominance on one side of the body; but this predominance is not constant, one time it is the right, another time it is the left side which is most attacked. It is a remarkable fact that in a given attack the limb which presents the greatest exaggeration of symptoms is also that which improves most rapidly.

The nervous phenomena which play so large a part in the attacks deserve our attention, because it is necessary to estimate precisely their value. Although the patient presents the attributes of the nervous temperament, everything up to the present illness had been limited to a simple predisposition. With the cyanosis of the extremities well-marked hysterical convulsions showed themselves, but let us note that these convulsions always accompanied the paroxysm of pains in such a way that it is legitimate to place them to the account of the latter, which would be only the occasional cause of them; then in proportion as the malady developed and became established the nervous symptoms became generalised and aggravated, aided by moral emotions of which the influence was undoubted.

Let us turn now our attention to certain remarkable circumstances in the local state of the affected limbs, and first with regard to calorification.

M. Landry observed with great acuteness that the moment of the greatest pain is marked by the change of colour of the

extremities to violet-black, and by a slight relative elevation of temperature, and that to the moments of remission there corresponded a deathlike pallor with cooling of the skin. This confirms the distinction which I have established between asphyxia and local syncope; in local syncope there is complete absence of blood; the fingers tend to assume rapidly equilibrium of temperature with the surrounding medium. In asphyxia there is a passage of venous blood, insufficient it is true to maintain a complete nutrition, but enough to preserve a certain degree of heat.

The sensibility entirely fled towards the deep parts; the finger, completely indifferent to superficial stimuli, was sensible to and even very painful on pressure. A somewhat exceptional circumstance was the improvement which the patient acknowledged was brought about by exposure to the influence of a low temperature. It is more difficult to give a reason for this than for the good effect obtained by cold irrigations. These seem to have had the results common to all hydropathic methods, that of bringing about a local reaction in the parts endowed still with sufficient vitality to respond to the action of stimuli.

As to the shrivelled aspect—the parchment-like character of the ends of the fingers—the fact is so conformable to what I have seen myself that I cannot but accept it as a faithful description of what actually took place. The whole process was terminated by a characteristic desquamation. There was nothing to lead to the belief that the tuberculisation to which the patient subsequently succumbed had any relation to the primitive malady.

We have now to deal with another observation which resembles in more than one respect the one which we have just read. To the cooling, the cyanosis, the mortification of the extremities, always imminent and never complete, were joined in this case also signs of hysteria, and further, a profound cachexia which the most rational treatment failed to cure. I shall have to discuss subsequently the nature, the progress, and the mode of evolution of this cachexia. I limit myself for the present to the exposition of the facts.

The patient who is the subject of this observation was for a long time an inmate of the Paris hospitals. I had seen her at the Clinical Hospital during my residence as interne under M.

Nélaton. When my attention was awakened to this curious affection I recalled my former patient. I discovered her with some difficulty, and persuaded her to come into the Necker Hospital, under the care of M. Vernois, on April 12, 1869. There she remained up to her death on the 26th July of the same year. The account of this case has been given by my friend Dr. Jules Simon, in his inaugural dissertation on leucocythæmia (1861). I shall discuss his interpretation of the case. To the notes taken by M. Simon I add the information which has been furnished me by M. Hérard, physician to the Lariboisière; by M. Péan, my excellent colleague at the Clinical Hospital, and finally the results of my own observations.

CASE IX.—*Chloro-hysteria; local asphyxia and very superficial gangrene of the extremities; transition into a chronic state; profound cachexia; death; autopsy.*

Anna B., aged 30 years, servant, born at Chabannais, Departement de la Charente.

This girl, born of poor parents, has been brought up in somewhat bad hygienic conditions; often maltreated by her parents she left them at the age of 16 years, in order to enter a position with easy employers, where she had better food and less fatigue. She began to menstruate at the age of 17 years with difficulty. The catamenia, although regular, were painful. She recalls having been since this epoch subject to suffocating feelings, and different symptoms of chloro-hysteria, dyspepsia, intercostal neuralgia, &c. Since then she has been liable to true hysterical attacks after emotional disturbances.

The commencement of the symptoms which subsequently brought her to hospital took place at Limoges.

She was then 27 years of age. For the last sixteen months she had partaken by preference of a bread made exclusively of rye flour. We are ignorant as to whether this bread was of bad quality or not. On the occasion of a severe fright her catamenia suddenly stopped, and at the same time the extremities became painful, and of an icy cold. She experienced in the last phalanges of several fingers, painful tinglings; at the same time the skin changed in colour, becoming pale and cold at some moments, blue at others. All the fingers were attacked in three days; the

finger ends became so insensible that objects touched and held up were not felt, and pins could be made to transfix the skin without causing pain. Nevertheless, although there was the loss of sensation of contact, the recognition of hot and cold was preserved. The only means which led to improvement consisted in warming the extremities with strips of cotton wool. On the eighth day there was a period of calm of somewhat short duration because it was followed by a recrudescence of the local affection, which lasted not less than eighteen months. The physicians whom she consulted at Limoges experienced doubtless the same difficulty which we encountered subsequently. It is certain that they enjoined the suspension of the use of the rye bread, thinking that this kind of alimentation might be adequate to explain the nature of the malady. The catamenia were suppressed from six to eight months; their return coincided with a remission of the symptoms of the extremities. Nevertheless she was not cured. She had been six months ill when she came to Paris, hoping to find some relief for her troubles. She entered the Lariboisière, where she passed eleven months. By degrees the second and first phalanges of the fingers had presented successively the same phenomena, that is to say, sensation of habitual cold, tinglings, slaty tint, incomplete anæsthesia at the moment of the attack, return of sensibility during the intervals, and then acute pains in the region of the punctures which had been made. Soon we saw bullæ appear at the extremities of the ungual phalanges; they passed from one to the other, and preceded the fall of all the nails, which came to pass in six weeks' time. Nevertheless they reappeared in less than two months. At the same time the left great toe was attacked with the same affection, which ended in the fall of the nail and its subsequent reproduction.

During the whole of the time of Anna's sojourn at the Lariboisière, M. Hérard, under whose care she was at that time, had treated her vigorously with tonics—Vallet's pills, quinine wine, &c. At the end of eleven months she left the hospital notably improved (August, 1858), and hoping to be able to resume her occupation as a chambermaid, which she had before followed with much ability. This hope was not of long duration, because on the 17th of December of the same year she entered the Clinical Hospital, where she stayed several months. We found

her in the following state, which I describe with detail, because it gives a picture of the disease at its maximum :—

Extreme pallor. The lines of the countenance are flaccid, and expressive of sadness.

So soon as she allows her hands to be exposed to a rather low temperature the fingers become pale, œdematous, half flexed; they are attacked with painful sensations, numbness, and torpor; shortly afterwards they become blue, then black, in their whole extent, and there are to be seen traced along the surface tracks like those of wine lees, which correspond to the veins, of which the course is very marked upon the back of the hand and up to the middle of the forearm, to a height which is quite symmetrical on the two sides. At the same instant the fingers present that insensibility of which I have previously spoken. The attack lasts so long as the patient does not take the precaution of warming artificially the suffering parts; it reappears indifferently by day or night, and rarely a day passes without her experiencing these symptoms. When she exposes her limbs to heat, everything returns in order, but very slowly; then the circulatory troubles seem to disappear, the sensibility returns completely, the black tint is effaced, but there remain traces of lines like wine lees over the fingers, the hands, and the wrists, as well as œdema, and here and there patches which seem to announce a relapse.

This is not all; bullæ are formed at intervals on the extremities of the fingers, upon the pulp which is situated at the end of the phalanges, and they are formed in this way: upon a single digit, or upon two digits at a time, the epidermis is raised by pus, so as to imitate a bulla, which develops, breaks, and leaves the derma naked. Eight days afterwards a cicatrix is formed, and this morbid process is repeated elsewhere. In front of the nail there is found a conical tubercle, upon which the nail, perfectly healthy otherwise, comes to press. The pulse is feeble, but very perceptible along the course of the brachial, radial, and ulnar arteries. These vessels are compressible, as well as the veins of the upper limbs, and in no sense give any sensation of a cord whose calibre is contracted.

In one word, we found nothing abnormal either in the heart or in the general circulation. The examination of the principal organs only gave negative results. The general condition, how-

ever, left much to be desired. Formerly she had been robust and stout, to-day she showed all the marks of confirmed anæmia.

To omit nothing, I will add that shortly after her admission into the hospital a large abscess formed under the sternomastoid. It was extensively incised, and the finger introduced by the opening penetrated into a deep cavity, so that the transverse processes of the cervical vertebræ could be touched. After this operation the abscess healed as if by magic. The treatment was limited to the continued use of the same means which had previously benefitted her (iron, meat, wine), but on the whole without any marked results. Nevertheless the patient went out of the hospital once more improved, but not cured.

In the course of 1859 she was in the Charité for a short time, under the care or M. Briquet. Almost the same symptoms, the same alternations of cold and heat of the fingers were observed. In addition, there was discoloration of the skin and of the mucous membrane, extreme feebleness, buzzings in the ears, a little deafness, vision troubled, small appetite, and constipation. No murmur was audible over the heart or the vessels of the neck; menstruation was slight and very irregular.

When in the month of April, 1860, an analogous case presented itself under my observation, I recalled the history of this unfortunate young woman, and I wished to know what had become of her.

After long searching I discovered her. She was in frightful privation. Incapable of working she had exhausted her last resources, lived on a few alms, and had not even nourishment sufficient for each day as it came. I decided to admit her to the Necker Hospital, under the care of M. Vernois (Salle Saint Anne). There we learnt what had happened to her. Shortly after leaving the Charité she had had modified small-pox, for which she had been treated at the Hôtel Dieu. In the month of January, 1860, she had had, on the news of the death of her father, a violent attack of "nerves," which had left her unconscious one night. This crisis, added to her miserable circumstances, had profoundly altered her health. Three weeks before her admission to the hospital she had had a series of attacks of epistaxis, which had ended in wearing her out. For several months the catamenia had been suppressed.

I examined her hands. The fingers presented indeed the

same bluish violet colour which had previously struck me, but it was less pronounced and more diffuse. The attacks which she had presented before, and which were so characteristic, had given place to a habitual lowering of the temperature of the extremities. But there was to be seen on the pulp of all the fingers a crowd of whitish, depressed cicatrices, somewhat analogous to those which are disseminated on the forearms of blacksmiths; these were the traces of numerous partial gangrenes, which had successively affected the different digits. We were also the witnesses of one of these attacks of gangrene. About one month after her admission into hospital we saw form on the little finger of the left hand, without appreciable cause, a small slough 1 centimetre long, 5 millimètres broad. This sore took five weeks to recover, including the time of cicatrisation. The extremities of the toes, which had never been anything like so bad as the fingers, were nevertheless withered.

The following is a summary of the condition of the principal functions: colour of face and of body excessively pale, and of a waxy yellow; mucous membranes discoloured; deafness very marked; extreme feebleness; inappetence; constipation; frequent vomiting; very soft murmur over the heart region; liver large, extending from the fourth rib down to the false ribs; spleen increased in size, easy to be felt below the thoracic margin, but difficult to define by percussion; pulse small, soft, but quite regular; nothing abnormal in the respiratory system; slight œdema of the lower limbs; feebleness, and mental weariness.

From the day of her admission up to her death this woman presented nothing special except a slow and progressive enfeeblement. In vain was she treated with every possible care. In vain was every kind of tonic and stimulant squandered upon her. In spite of the excellent hygienic conditions in which we endeavoured to place her, nothing could re-animate this profoundly exhausted organism. In the last part of her life vomiting became incessant. She ended by succumbing in the last stage of cachexia, on the 25th July, 1860.

It would have been desirable that a chemical examination of her blood should have been made. But her extreme anæmia not permitting such an examination, we were obliged to content ourselves with placing under the microscope a few drops of blood

extracted by the prick of a pin. The red corpuscles were much diminished in number. The white corpuscles were present in the proportion of 1 to 15 or 20 red, and ultimately they were in the proportion of 1 to 5.

The autopsy was made with the greatest care. I have borrowed the details from M. Simon's thesis :—

Body ex-sanguine, pale; spleen, length, 20 centimètres; breadth, 12 centimètres; thickness, 6 centimètres; weight, 1 kilogramme.

Liver, antero-posterior diameter, 24 centimètres; transverse diameter, 24 centimètres; thickness, 8 centimètres; weight, 3½ kilogrammes.

Mesenteric glands pale, larger than normal, but only few in number. Nothing abnormal in the intestine or in the lungs, which show great discoloration. The pleural cavities contain several spoonfuls of yellow fluid, no adhesions; the kidneys, a little enlarged, are pale, but not granular; the pericardium contains a little fluid; the heart is of good size, but presents pale and soft fibrés, and contains dark diffluent currant jelly clots; There exists much fat over the heart, as also in the subcutaneous cellular tissue.

Uterus healthy and small, with a small extra-uterine fibroid attached to it; the brain shows nothing special.

Further examination of the spleen by M. Simon gave the following results :—

It capsule is thickened, opaline, difficult to strip off; on section the spleen substance is of firm consistence, elastic, like caoutchouc, and allows the finger to penetrate it with difficulty. To the naked eye and with a lens one distinguishes very easily that a red vinous coloration is present over the whole section, on which stand out the trabeculæ and an infinite number of marblings, patches of yellowish white, half to one millimetre in diameter, rounded, some angular, and placed at a very short distance from one another.

This spleen tissue cannot be compared with anything more justly than that of a liver attacked with advanced cirrhosis. With the microscope, besides deformed and scanty red corpuscles, and very abundant white corpuscles, we find in the splenic tissue much fibro-plastic material, many fusiform fibres, cells, and nuclei.

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This hypertrophy is not a simple one, it is accompanied by infiltration of plastic lymph unequally diffused. The small patches seen on section before referred to are Malpighian bodies altered, infiltrated with lymph, and containing many white corpuscles.

I shall complete this pathological description by adding that the arteries were healthy and patent. Having detached from the body one of the upper limbs, I introduced into the brachial artery a vermilion-coloured injection, and neither in the calibre nor in the shape of the arteries which arose from this trunk, and which I dissected with care, could I discover anything which in the way of material obstacle to the blood current could explain the production of this strange malady.

This case amongst those which I have personally observed being the only one which was completed by microscopic examination, I ought in the first place to state what was suggested by the results of the autopsy.

As we have seen, the results are absolutely nil in so far as the circulatory system is concerned. The heart was of ordinary size and extremely flabby; but there is nothing in this fact which is not common to a crowd of very different pathological conditions, and it ought not to surprise us after the long and profound exhaustion from which this patient had suffered. We may say as much with regard to the excessive fatty envelopment (I do not say degeneration) of this viscus.

The complete integrity of the arteries is not less remarkable. There was no appreciable narrowness of these vessels. The only interesting lesion is the enormous size of the spleen and its fibrous structure. It is especially this consideration which has led M. Simon to consider Anna B.'s case as one of leucocythæmia; and it is certain that taking this word in its etymological sense, the relative abundance of white corpuscles would justify its being quoted as an example of the disease. But the point is whether leucocythæmia is indeed a disease properly so-called. Without entering into a discussion upon this burning question, I will only say that what has been described under this title of late, has seemed to me to be only a condition (real no doubt, but also probably very common) of the liquids of the organism, an ultimate condition which has only an anatomical signification, and to which many cachexias of

most diverse nature can tend. This is indeed precisely the way in which the author whom I have just quoted regards it. Thus far I am in harmony with my colleague. If I diverge from him it is when he appears to consider the affection of the extremities as one of the symptoms of leucocythæmia. Is it not more rational to admit that in this case, the primary fact was a profound trouble of nutrition, the cause of which was inexplicable, but the manifestations of which were on the one side local asphyxia and superficial gangrene of the extremities, and on the other side aglobulia, leucocytosis, hypertrophy of the spleen and of the mesenteric glands; the whole of which ought to be placed upon one basis? And if we must assign the order of appearance of these different phenomena, it is probable that the establishment of the cachexia was much posterior to the symptoms relating to the extremities, and that the free nose bleedings which characterised the month of March, 1860, were only the first symptom of the congestion of the liver, and perhaps also of an already advanced alteration of the blood state. The various disturbances of innervation shown by this patient were intimately allied to anæmia; the deafness and the mental disturbances differed in no respect in this case from what one observes in many chlorotic subjects. Let us note that the only improvement at all definite, was obtained by the prolonged use of all kinds of tonics, so that in spite of the fatal issue it would appear that tonic treatment was the proper indication.

In this case once more the local state presented several special features worthy of attention. This woman was one of those who present in a very high degree those marblings analogous to what are found in persons who habitually use foot-warmers, a certain indication of a venous stasis. Her sensation presented during a certain time an odd character which is not very rare; I refer to complete anæsthesia and analgesia coinciding with integrity of the sensation for temperature.

To the tapering form and shrivelling up of the ends of the digits was added a remarkable tendency to the formation of bullæ, which affected not only the epidermis but also the most superficial layer of the true skin, as attested by the numerous small whitish depressed cicatrices. We must in pathology take note of shades of difference; if there is not identity there is at least much analogy between the preceding case and the following. I owe

this case to the kindness of my excellent master, Dr. Gubler. He has been so good as to add some observations, which I reproduce with the more pleasure because they support my own view with the weight of a considerable authority.

'The part played by arteritis and arterial obliteration in the production of the spontaneous gangrene which is called senile is probably less than we think.' 'Such at least is the opinion which I have endeavoured to set forth in my *Lectures on General Pathology* (1858—59).' 'One fact amongst others of which I was witness sixteen years ago at the Salpêtrière convinced me of the necessity of taking note of other conditions than the suspension of the course of the arterial blood in the pathology of dry gangrene.' 'An old woman in the infirmary, under the care of one of my masters, M. Natalis Guillot, had suffered for several days from pains in the lower limbs.' 'It seemed to her, as she expressed it, that dogs had been set to gnaw her feet, and already we ascertained that there was chilling of the lower extremities and a cyanotic tint of nails and skin, sure indices of approaching mortification.' 'Nevertheless the dorsal arteries of the feet and the posterior tibials pulsated as usual, and they presented no obvious modification of structure.'

'This was still the case for one or two weeks longer, although the tearing pains persisted to the same extent in spite of treatment, and the cyanosis and cooling became day by day more pronounced.' 'Finally sphacelus commenced, followed the usual progressive course, and soon brought the patient to the grave.'

'In this case arterial obliteration, at least obliteration of the arteries of a certain calibre, not having preceded, but having on the contrary succeeded the phenomena of mortification of the tissues, it is evident that one ought not to attribute the mortification to interruption of the blood current in such arteries.'

'I had an impression that the mechanical obstacle might exist in a multitude of small canals at the same time, that the hæmoplastic coagulation might have started in the capillary network, passing thence to the arterioles and the arteries of a larger calibre.' 'However this may be, the coagulation itself was only a secondary phenomenon, of which the probable cause was to be found in modifications in the circulation, and calorification of the affected regions brought about by nervous disturbances.'

'The neuropathic element would, according to this view, play an

essential part not only in the sphacelus of ergotism but in the senile gangrenes.' 'A case which subsequently came under my notice, and which I described to the Société médicale des hopitaux and also to my class, confirmed me in the opinion which I had formed respecting the importance of the nervous system in the production of certain spontaneous gangrenes.' 'The following is a summary of it':—

CASE X.—*Neuralgic pains in the four limbs, more violent on the right side, especially in the foot and the leg; gangrene of the second right toe limited to the ungual phalanx; elimination of the slough. Death from exhaustion.*

Mlle. X., native of the south of France, of a moderately strong constitution, with a temperament predominantly lymphatic and nervous, enjoyed up to the age of 40 years fairly good health. When 20 she had given birth to a female child. No definite evidence could be obtained that she had had syphilis, although some circumstances of her life rendered this possible. As to the hereditary antecedents I ascertained nothing more than the existence of paralysis agitans in the father of the patient. In 1853 Mlle. X. began without known cause to feel pains in the limbs, which soon became sufficiently intense to spoil her sleep. Nevertheless being in want, she at first neglected her health, and whilst suffering these pains she came to Paris in the hope of finding occupation there. Mlle. X. had in fact a certain talent as a sculptor. Her hopes were not realised, and the disease making progress she applied to my regretted master, Dr. Lallemand, whom she had known as professor of the faculty at Montpellier. Lallemand, already suffering himself, entrusted me with the care of treating this poor woman after having visited her for awhile, and took me for the first time to see her on the 3rd August, 1853. For more than six months the pains had been intense and all but intolerable. They affected the four limbs, but to a greater extent the lower than the upper, and the right limbs more than the left; they were also more violent by night than by day. The patient was extremely thin, not only by loss of fat, but also by the muscular wasting, which was very pronounced. Her countenance was expressive of suffering; her colour was yellowish; the cheeks, nose, and forehead were covered with tubercles of acme rosacea. Seated in

bed, the body leaning forward, the lower limbs flexed and drawn up towards the hands, she rubbed without ceasing one or other leg, the right principally, whilst agitating the trunk by alternate movements of flexion and straightening, and giving utterance each moment to a continued moan or to a rending cry extorted from her by the violence of the pain. It was thus that the unfortunate creature passed sometimes the greater part of the day and night. At times the crises were appeased, a little calm returned, Mlle. X. took a little nourishment, and allowed herself to gain a little relief by sleep; but soon roused again she found herself a prey to the same tortures as before. Examination of the principal viscera revealed no organic lesion or tumour either in the cavities or on the surface of the body, not even the trace of an exostosis. The principal functions were performed regularly during the intervals of the neuralgic paroxysms, and if the general strength was diminished the motor power was at least only slightly lessened even in the right lower limb, which was principally affected. Cold water, general baths, antispasmodics of all sorts, and narcotics in ordinary doses only having produced a momentary improvement, I attempted the employment of sulphate of quinine, with a success of too short duration to justify its continuance. Finally discouraged, I renounced all fresh attempts, contenting myself with prescribing stronger and stronger doses of extract of opium, of which the patient took successively from 10 centigrammes up to 1 gramme and more. Thanks to this narcotisation she barely succeeded in obtaining some remission in the tortures which she endured habitually. Many months passed without any fresh incident; but at the commencement of 1854 I perceived one day a lilac tint on the second toe of the right foot, in which the patient experienced the most severe shooting sensations. This toe had been for a long time the seat of more intense pain than the others. Simultaneously with the appearance of this lilac colour it was also found that the temperature of the toe was very low, and the capillary circulation was so slow that a white patch produced by the pressure of the finger took about half a minute to disappear.

With these signs it appeared certain that the case was one of spontaneous gangrene. Nevertheless the principal arteries of the limb carefully examined, appeared quite normal; the dorsalis pedis, the posterior tibial, the popliteal and the femoral below

the ring presented pulsations as strong as in the corresponding arteries of the other side, and there were no modifications either of form or consistence to be made out. In spite of the application of warmth and local stimulants the sphacelus became more and more characteristic after a few days, and a greyish dry slough soon formed at the extremity of the toe, occupying a large part of the ungual phalanx. Strange to say the gangrene limited itself to this small region, an eliminative inflammation developed around the mortified tissue, which was detached at length. The loss of substance left a bare surface, at the bottom of which we discovered the phalanx denuded and partially necrosed. Nevertheless the pains were not lessened in severity, and the patient's strength was rapidly becoming exhausted. Mlle. X., no longer trusting in my treatment, gave herself up to less rational measures. I ceased attending her on the 1st August, 1854, but I learnt subsequently that she had succumbed to marasmus in a few weeks.

'Here then,' adds M. Gubler, 'we have a case of gangrene with the absence of any obstacle to the arterial circulation; it is associated, on the contrary, quite naturally with disorders of innervation.' 'By what mechanism?' 'That is a difficult question to answer.' 'If we believed in the necessity of the constant intervention of the nervous system in the reparation of organs, we might have supposed that in this case there was a cessation of influence on the part of the trophic nerves.' 'Without going so far, it is rational to seek the cause of the mortification in some morbid condition of innervation whether one admits a local loss of strength in consequence of the pain, or rather attributes the cessation of life in the gangrenous part to an impediment to the arterio-capillary circulation determined by some permanent affection of the vaso-motor nerves.'

This is the first time that we have met with a clear case of dry gangrene inducing the loss of a portion of the digit. It is to be observed, however, that one toe only was affected; thus this case, at once more and less complete than the others, is somewhat difficult to classify. Nevertheless, when we consider both the integrity of the arterial pulsations, and the distribution of the painful precursory symptoms of gangrene in the four extremities, we are strongly inclined to the view that the gangrene existed, so to speak, potentially in all the limbs, and that some unperceived

cause, perhaps a simple local irritation, may have determined in the second toe of the right foot a more complete manifestation than in the others.

III. *Symmetrical Gangrene of the Extremities of Benign Form.*

CASE XI.*—*Syncope and local asphyxia; gangrene of the skin of the extremities; bleedings; cure.*

A countryman, aged 40 years, a thrasher in a barn, who lay in bed No. 70, Salle Sainte Marthe, was attacked in both hands and feet with that rare variety of dry gangrene which some authors have called white. The disease lasted four years, and presented a succession of symptoms which were somewhat remarkable.

Present state: fingers white, and cold to the touch, like ice; the extremities of the second and third fingers atrophied and mummified; the shape of each finger conical, fusiform; the nails raised up, and showing slight traces of suppuration at their lower border; there is almost absolute impossibility of flexing the digits; there is complete insensibility of the last phalanges, and a feeling of tingling and of cold in the remainder of the digits; skin white and hard, like parchment; absence of pains,† and absence of gangrenous odour. The feet present almost the same anomalous conditions, especially a glacial cold to the touch, impossibility of flexion, great difficulty in walking. The ears, the nose, and the lips of this individual present a remarkable want of vitality and of warmth, but to a less degree than the hands. The radial pulse can be felt. The heart beats strongly, and is somewhat irregular. Otherwise the functions of this man are performed perfectly; he does not consider himself ill, and but for the impossibility of using his hands during the last four years he would not have come to Paris for treatment.

Past condition: this illness, we have said, dates back for four years, but it has not been continuous; it has shown itself at certain times of the year, disappearing at others. During the

* By M. Rognetta, *Revue médicale*, T. i., p. 368, 1834. This case, obtained from Dupuytren's clinic, is entitled by the author "White Gangrene"—a vicious title in every respect, because this word has an accepted sense; but the phenomena described have no relation with the white gangrene of Quesnay.

† It is supposable that there had been pain.—R.

great heats of summer it was most frequently present—precisely when the patient was obliged by his occupation to be exposed to the sun.

During the first year or two this condition of glacial torpor or asphyxia of the fingers only lasted a few days, but the present attack has lasted for four months, in spite of all the remedies which have been employed. Whenever the affection does not disappear spontaneously, nothing can make the fingers become warm.

The etiology of this singular malady is very obscure. All our questions concerning the nature of the food—and especially as to the kind of bread, fruits, and vegetables of which he has partaken—have taught us nothing as to the causes of his illness. It is to be remarked that in his occupation as thrasher at a barn this individual has been exposed to severe changes of temperature. Otherwise he had always enjoyed the best health. Moreover, does not the form of this affection authorise us to consider the illness as a veritable asphyxia, due to some internal cause, in which the life of the digits, without being completely extinguished, is found, so to speak, in a state of coma?

Considering the illness in question as an affection of the extremities of the capillary arterioles of the fingers (which would only itself be a symptom of a disease of the heart), M. Dupuytren employed for it the treatment which he usually employs against senile gangrene (bleeding from the arm, local poultices, moderate regimen). In eight days of this treatment the heat, the colour, the motility, and the life of the hands and feet of this man returned as by magic; the fingers seemed even to have lost a part of that conical form which they had had before the treatment. The patient was counselled to have recourse to the same remedies if the affection should reappear at a later period.

M. Rognetta accompanies the record of this case with the following remark: In medicine especially, we may say with Voltaire, that "Systems are like rats, which can escape by twenty different holes, and find at last two or three which will not admit them." Here, however, is one of those cases in which for the hundred and first time the theoretical views of M. Dupuytren on spontaneous dry gangrene are applicable without any restriction, and are followed by success. What is to be thought of this? We must be strongly prejudiced in favour of

the views of the master if we find here a confirmation of the doctrines of Dupuytren, the great apostle of arteritis, as every one knows. I may perhaps be accused of prejudice in the opposite sense, but it seems to me that the "system," of which I do not deny the intrinsic value, has undoubtedly in this case met with a "hole" through which it cannot pass. In any case it must be admitted that the success of the general bleedings (if it is indeed to them that we must attribute the cure) would not suffice to establish the existence of an arteritis.

I now record two cases which I observed at the Hôpital des Enfants Malades, the one in 1860 during my internat under M. Bouvier, the other quite recently in M. Roger's ward. These two cases require to be compared one with the other, because they are mutually complementary. I shall be pardoned, on account of their importance, for the minute details into which I have entered relating to the local state of the diseased parts.

CASE XII.—*Local asphyxia and superficial gangrene of the skin of the lower extremities; traces of the affection in the upper limbs. Recovery.*

Georges G., 3½ years old, admitted May 16, 1860, to the Hôpital des Enfants, under the care of M. Bouvier.

A puny child of brown skin and extreme emaciation, with frontal bosses much developed, cheeks hollowed, aspect of the face somewhat singular; on the first look one would regard the child as an idiot, but on getting him to talk we find that this is not the case. His parents are healthy, there is no evidence of syphilis. The child has a sister who was attacked with scurvy at Lyons during the inundations of the Loire, and who has now vertebral disease dating from when she was 18 months old.

He remained out to nurse up to 3 years old in the Department of Cévennes; he was weaned at the age of 7 months. From that time his nourishment was that of the peasants of the district; it consisted in chestnuts boiled in milk, very black bread, made chiefly of buckwheat, and with a certain proportion of rye (about which one could never ascertain whether it had been altered or not), sometimes vegetables, potatoes, rarely meat. He often slept outside with the shepherds. He had never had ague or convulsions; the only illness of which they had any knowledge was a suppurating gland whilst he was being nursed. Since his

return to Paris, eight months ago, he has always eaten white bread; he has been very ravenous. Almost immediately he began to waste, and this has been very marked during the last month. Three weeks ago both legs began to swell, and two or three days afterwards the extremities of the toes became blue, at first clear, then deep, then of an inky colour; this occurred in both feet. Then on the left side the illness followed a retrograde course, passing through the same phases as in its period of increase, but in a reverse way. But on the right side the lesion became more pronounced; there was during three or four days a slight blue tint of the extremities of the fingers of both hands, well marked, especially over the nails; he had no affection of the nose or of the ears. Whilst these symptoms lasted there was some prostration. The child groaned, complained much during the night, without referring specially to pains in the extremities. His father, who examined his pulse, found it irregular and intermittent. The extremities were cold; there was no fever.

There were now ten or twelve days during which the blue colour was succeeded by definitely black patches on the right foot.

The following note was taken on May 16: the three first toes present at their extremity, under the edge of the nail, a very limited patch of a bluish black parchment-like character, slightly rough. The anterior part of the nail participates in this colour in consequence of its transparence. The fourth toe presents only a slight coloration under the nail. The lesion occupies the anterior quarter of the little toe, passing behind the nail, which is entirely black. This toe is as black as charcoal; the bits which one detaches from it by scratching, are white. There is nothing similar on the extremities, but there is a small eschar in process of cicatrisation over the point of the coccyx.

Pulse perceptible in the femorals, the dorsalis pedis, even on the diseased side, and in the two radials. The pulse, which is 96 in the minute, presents remarkable irregularities. Every three or four, sometimes every ten pulsations, there is a slight retardation; sometimes thirty pulsations take place regularly, then occurs an intermission; besides this there are moments when the pulse is very sensibly accelerated, and then becomes slowed; it varies also in force. When the radial pulse and that of the dorsalis pedis of the diseased side are examined simultaneously there is found from time to time a perceptible pulsa-

tion in the first of these two arteries and not in the second. *Vice versâ*, there is more rarely a pulsation which is more feeble in the radial than in the dorsalis pedis, but I have never found it fail entirely in the radial. Auscultation of the heart furnished nothing remarkable beyond the intermissions corresponding with those of the pulse; auscultation of the lungs gave nothing abnormal.

May 23.—The child has fever and prostration. On examining it we find a large inflamed gland under the sterno-mastoid of the left side. This abscess was opened eight days afterwards. A second abscess formed in the neighbourhood was similarly opened, and recovered rapidly.

As to the affected foot, this was the condition on the 5th June: all around the black patches the epidermis is raised for a breadth of about half a centimetre, and completely detached. On the big toe the slough has fallen, and is replaced by a delicate rosy epidermis. The nails just preserve a very slightly dark tint. The fourth toe, which had no slough, is desquamating like the others.

June 12.—All the toes are entirely clear except the fifth. This subsequently became quite healthy, and the child quitted the hospital, July 5, in very good condition.

I had news of him on December 12, 1861; he lived at Orleans; had not been ill since leaving hospital, was strong, and developing rapidly.

CASE XIII.—*Local Asphyxia; superficial gangrene of the lower limbs with very marked tendency to symmetry.*

Cecile B., 8½ years, an orphan, admitted November 28, 1861, under M. Roger.

We have no information as to the illnesses of which the parents died. The patient has a brother aged 10 years, who is healthy. Born at Versailles, she left that town after the death of her parents four years ago. She lived some time at Paris, then at Bourg-la-Reine. Since the end of last summer she has been with the Sisters of St. André at Ivry. In these different residences she has always had good food, and has never eaten anything but white bread. Hitherto she has only had slight indispositions; she is very subject to colds in the head; she had ringworm for one year, which lasted up to a month ago.

She is in good condition, and has the signs of the lymphatic temperament; bluish cornea, long eyelashes, very red cheeks, and is fairly intelligent.

November 28.—About eight days ago she began to feel pains in the feet, and up the lower half of the legs; at the same time the ends of the toes became violet or red. It was believed at first that these were due to chilblains, the more so that she always suffered badly from chilblains during the winter, and required special dressings for them. Nevertheless there has been no excessive cold this year, the child has not been exposed to a low temperature, and her feet have always been washed in hot water.

The pains becoming more and more intense she was taken to a doctor, who recognised the gangrene, and considered it necessary that she should be admitted to a hospital. On the day of her arrival she suffered a great deal. In the evening, in order to soothe her, poultices were applied; far from being relieved she passed a very bad night, and had some fever.

Actual condition. Right foot: on the great toe a livid red patch of the size of a 20 centimes piece; behind this, and upon the inner surface of the pulp, another similar patch. Areola of a livid red, 1 centimètre broad, around the base of the nail; on the second and third toes very small red patches on the dorsal aspect of the two last phalanges; the fourth toe is darker, of a slaty colour, not becoming pale on pressure, passing into red near the base of the toe, and this shade is continued up to 3 centimètres backward; little toe of a sombre red.

Left foot: broad violet patch occupying two-thirds of the pulp of the great toe, epidermis slightly raised; second toe healthy; third presenting a black patch on the plantar surface, and redness on the dorsal surface; on the fourth a broader patch, slate coloured, with a completely black area in the centre; it extends for a short distance; almost nothing on the fifth.

The gangrenous spots are insensible, but the patient dreads the concussion which results from the least touch. Arterial pulsations very perceptible and regular in the dorsal arteries of both feet, in the posterior tibials, as well as in the popliteals and femorals.

The tension of the abdomen prevents our feeling the aorta. Pulse 100 to 102; skin cool; nothing abnormal with respect to

the heart; on the outer side of the right middle finger, but not at the extremity, there exists a small bluish patch, surrounded by an inflammatory areola, and which resembles in appearance a scrofulous lesion of the skin.

November 30.—The same condition. To-day we note in addition, symmetrically under each heel, a livid patch of the breadth of half-a-franc piece; on the left there is in addition a second extremely small patch, situated at a little distance in front of the first. M. Roger ausculted and percussed the heart region, and discovered nothing abnormal.

December 2.—Nothing new; the pains continue, especially at night; good appetite, no diarrhœa; symmetry in the lesions of the extremities is more pronounced.

December 4.—She has had again sharp pains in the night; the lesion is at its maximum on the fourth toe of each foot; the pulp is hard, shrivelled, black like charcoal; this is more marked on the right than on the left side; then come the two great toes, which present, one on its dorsal surface, the other on its plantar surface, more or less extensive bullæ. The second and third toes present only insignificant excoriations, and on the left side a thick inspissated liquid somewhat like plastic lymph oozes out between the toes.

December 6.—The pains have ceased; the mortification is now well limited.

December 7.—Urine, specific gravity 1022, no trace of sugar. No reduction with Fehling's solution, no brown coloration by caustic potash.

December 9.—The pains have not reappeared. On the right side the red tint at the base of the fourth toe has been followed by a faded leaf colour; the skin there is parchment-like; the great toe presents fine brown marblings.

On the left side the broad bulba of the great toe has withered up. The gangrene of the fourth toe is still more pronounced.

Up to the 15th the symptoms continued to improve, so much so indeed, that on that day the child could raise herself, and walk easily.

December 18.—The toes are desquamating freely; from several of them broad dry brownish pellicles can be partially separated. Where these small superficial eschars have greater thickness we find the derma underneath of a pale violet tint.

On further examination it is clear that the rows of papillæ have undergone some loss of substance, and are less obvious than those in the neighbourhood. There is desquamation over both heels; the livid patches previously noted have disappeared; there is slight desquamation of all the fingers of the right hand.

December 23.—The black slough of the fourth right toe, which was the largest of all, and from under which pus has oozed for several days, is now completely detached; on its removal fleshy granulations are to be seen.

December 28.—The superficial wounds suppurate, and tend rapidly towards cicatrisation.

The child went out cured January 18, 1862.

Returned to the hospital February 12. During the day of the 9th, the external temperature being moderate, and without appreciable cause the child began to feel pains in the right foot, but of much less intensity than during the first attack; these pains lasted three days. The third right toe presents under the edge of the nail a small fringe of livid colour, of which a part is raised in the form of a bulla, and on its dorsal surface there is a little greyish patch; there are slight traces of mortification in the fourth toe. In the left foot the toes are healthy; on both heels, and on points symmetrically placed, there exist brown irregular patches to the number of seven or eight on each side; besides this, one remarks on the plantar surface of the metatarsus a certain number of very small gangrenous patches. Otherwise the general condition is excellent; the pulsations of the heart are normal as well as those of the dorsal arteries of the feet; there is no fever; the appetite is good. This relapse is in one word the diminutive of that which was observed two months ago; the toes previously diseased present slight honeycombed cicatrices; everything points to an early cure.

IV. *Symmetrical gangrene of the extremities of grave form.*

CASE XIV.*—*Gangrene of the fingers of the two hands from syncope and local asphyxia at the epoch of the menopause.*

Mme. D. came to consult me on several occasions at the end of the summer of the year 1849. She was then 48 years old.

* By M. Gintrac, *Cours théorique et clinique de pathologie interne et de thérapie médicale*, vol. iii., p. 420. Paris, 1858.

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After having had during three years very abundant catamenia she had arrived at the critical age. Some little time afterwards she felt cramps and glacial cold in the fingers of the two hands; the digits became very pale, the little finger of the right hand showed a patch of less than a centimétre in diameter on the dorsal side of the last joint, but soon afterwards the extremity of the middle finger and of the ring finger became gangrenous and dried up. This malady had progressed very slowly. It had lasted for ten months when I saw this lady. The affected fingers had lost their extremities up to the level of the terminal articulation; cicatrisation had advanced in some measure under the scar. There was commencing gangrene in the pulp of the right index finger; the left index and middle fingers showed a similar condition equally limited to the pulp. On the scar being detached, the nail corresponding to it was found curved so as to accommodate itself to the new form of the extremity of the finger.

The thumbs and toes took no part in the progress of the disease, but the patient felt sometimes prickings in them. I recommended infusion of cinchona bark with a little opium internally, and for external use lotions of decoction of cinchona bark with a little camphorated spirit added to it.

This gangrene was absolutely dry, without odour, without suppuration or putrefaction; there were neither febrile nor nervous symptom; there was no swelling or redness of the hand or the fingers. The temperature of the affected fingers was a little cool, but almost normal; the pulsations of the radial and ulnar arteries were easily felt. This woman, who is of a sanguine temperament, with habitual injection of the capillaries of the face, has enjoyed good health. Examination of the heart revealed nothing abnormal about that organ; there was neither dyspnœa, cough, nor palpitation; the digestive tract was in good condition. The patient's habitual mode of life was healthy and regular. She had been lowered by previous treatment, but tonics very quickly improved her general condition. Mme. D. was able to attend to her occupations as the mother of a family; her recovery was quite satisfactory, and her health has been good for the last three years.

This case interested me very much. My endeavours to ascertain the causes of the gangrene were altogether fruitless. If this woman had had any previous illness one might have regarded

the mortification of the fingers as a critical and salutary (?) effort, because it proceeded in a benign way, but nothing in the antecedents authorised this supposition. Although occurring after immoderate catamenia, this affection did not appear to be an effect of anæmia. Although preceded by tinglings and pains the mortification was not a purely nervous phenomenon; the patient had never presented ataxic or hysterical phenomena, and subsequently she presented nothing which could have justified the suspicion of a trouble of innervation. There was no evidence of a phlegmasia of the arterioles; the fingers were from the first pale and cold.

Finding no alteration in the functions of the solids of the body adequate to the explanation of so singular a condition, I should place its cause in some alteration of the liquids, and especially of the blood.

I come finally to the case which was the starting point of my researches upon this obscure question of pathology, and which I give as the most complete type of the malady under discussion.

CASE XV.—*Local asphyxia of the feet, hands, nose; dry gangrene of the four extremities, going on to the fall of many portions of the ungual phalanges; the whole supervening on a recent parturition. Recovery.*

Mme. E. X., aged 27, dark, well built, of a clear complexion, enjoys habitually excellent health. Some tuberculous antecedents on the mother's side. Menstruation regular since the age of 14 years; the catamenia last about five days. No serious previous illnesses; she has had mild attacks of most of the eruptive fevers; never any nervous attack; extreme proneness to chilblains. During the summer, the hands are habitually very red; this was especially marked during infancy; frequent sensation of dryness at the ends of the fingers, which has induced the habit of often putting the tips of the fingers in the mouth. I think we ought to note these slight predispositions, which seem to indicate an exaggerated susceptibility on the part of the extremities, and which would not merit our consideration but for the grave symptoms which have subsequently supervened, and have recalled these facts, of themselves unimportant. At the end of October, 1859, Mme. X. had her first confinement, which took place very satisfactorily. At the end of three weeks she was in a condition to set out to Italy with her husband. The

catamenia reappeared six weeks after her confinement; but she had only two periods, and became pregnant again. The pregnancy progressed favourably in spite of much worry.

Mme. X. returned to France in the month of August and gave birth to a daughter at Paris, November 28th, 1860. She took during her labour about 1½ gram. of ergot. In spite of her good constitution she had no milk after this labour, any more than she had after the preceding one. Three days after her confinement, which had a moderate duration, without severe pains, M. Vernois whilst feeling the pulse, was struck by the marked intermissions which occurred at every 4 or 5, sometimes every 8 or 10 beats. He ausculted the heart; this organ presented nothing special except the intermissions corresponding to those of the pulse. The patient was aware of these intermissions, which were made manifest to her by a sensation of pulsation in the head; she assured us she was subject to them. All that we know is that the pulse had not been examined since the first confinement, and that then, there was nothing of the kind. On the eighth day after her confinement the patient was taken suddenly during the night with a choleriform attack of the greatest gravity. There was chilliness, incessant diarrhœa, smallness of pulse, faintness, and abdominal pains. At the same time there was complete suppression of the lochia, which the day before had presented a remarkable fœtor.

The patient was wrapped in warm cotton wool; poultices were applied over the abdomen; internally opium was given in full doses. About seven or eight o'clock in the morning a period of reaction began with fever and moisture of skin. The day passed pretty well; the serious symptoms subsided; the diarrhœa persisted still a few days, then became arrested; the lochia did not reappear.

Nevertheless convalescence was slow and difficult. The patient complained of great feebleness. At the end of a month she was still in bed, and it was necessary in some degree to compel her to get up. She complained of vague pains in the lower part of the abdomen, and on examination a slight degree of anteversion was found with engorgement of the pelvic viscera.

February 15.—Feeling much better she got up and went to church for the baptism of her child. She experienced great fatigue from this.

February 18.—On awaking she felt itching at the end of her fingers; she thought her hands were chapped and put on some gloves, but in the evening she found them too tight and felt her hands swollen. The following days the ends of the fingers became a little red and painful; she was obliged to cease playing the piano; she had difficulty in eating; she could no longer sew.

M. Hervez de Chégoin, who saw her then, on account of the persistence of the uterine engorgement, prescribed iodide of potassium internally and externally. This treatment was commenced on the 4th of March. The abdominal pains diminished with great rapidity. At the same time the pains of the fingers increased more and more; the extremities became bloodless, then assumed a clear blue colour, which went on deepening from day to day. The forearms were covered with a lichenoid eruption, which might well have been only the result of iodism. The iodide of potassium was suspended on the 16th March. At this epoch the malady affected the whole of the first phalanges. They had a blackish colour, which one could not compare to anything better than a finger stained with ink, and from which the ink had been only wiped off superficially. During these early days, yielding to the idea of waking up the vitality of the extremities, I persuaded the patient once to plunge her hands into mustard and water. I was frightened when at the end of a few moments I saw the upper limbs up to the forearms become extremely black. One may well believe that I was not tempted to renew this attempt.

March 22.—The affection progresses every day. Violent pains, absolute impossibility for the patient to use her hands. The extremities of the toes have begun to be painful.

March 26 and 27.—Pains most severe, returning in crises of an intensity truly frightful, drawing from the patient, who is generally gentle and patient, yells of suffering, depriving her entirely of sleep. There is a sensation of persistent burning with exacerbations without any fixity in the return of the attacks.

March 28.—The blackish coloration of the extremities continues its invading march. The black parts are cold to the touch, covered with a viscid sweat. In one word, it is altogether the aspect of limbs in which gangrene is imminent. The ex-

tremity of the nose presents in its turn a blackish coloration, which is exaggerated during the attacks of pains; one sees then marked out under the skin at the root of the nose great livid veins with contours badly defined. No pains in this situation; but the patient recalls now that about fifteen days ago the extremity of the nose became painful to the extent of preventing her from blowing it. Let us note in passing that just four months have elapsed since the confinement, and that the catamenia have not yet returned.

March 29.—Consultation, in which Messrs. Vernois, Barth, and Hervez de Chégoin took part. These physicians found matters in the following condition: the black coloration of the hands has attained its maximum; it occupies the two last phalanges entirely, and has no precise limits; the nails are entirely black. The heart, which has moreover been constantly examined since the commencement of the illness, presents nothing abnormal. One can count more than a hundred pulsations without finding the least intermission; thus the phenomenon, which four months ago gave us the first warning, has completely disappeared. The pulse felt at the radials and ulnars is full and regular. Examination of the brachials at their origin gives the same result. If the two arteries of the forearm be firmly compressed so as to intercept the circulation it produces no change in the coloration of the digits. If the compression be made directly upon the digits it produces at the compressed spot a dead white patch which takes a considerable time to disappear (about one or two minutes). The same phenomena occur as on a healthy limb, but with extreme slowness. This slowness of the capillary circulation does not appear to be related to an obstacle on the venous side, because there is only the slightest possible fulness; there is no œdema properly so called. There is slight increase of temperature of the wrists and palms of the hands. The severe pain prevents our examining the sensibility completely. It is found that the touch is extremely blunted; she feels as through a thickened skin. Further, she experiences spontaneously odd sensations; she believes at times that both her fingers are crossed one over the other, although there is in reality nothing of the kind; she "feels the circulation of the blood in her fingers," &c.

The pains begin to be very violent in the feet. Walking is

still possible if the toes are raised so as not to touch the ground. The last phalanges of the toes are entirely black save those of the great toes, which present rather a livid greenish colour. The condition of the nose is stationary. There is nothing abnormal about the ears. In the midst of this appalling group of symptoms the patient preserves a remarkable integrity of the other functions. She eats with appetite and digests well. The colour of the face retains all its freshness, which contrasts strangely with the dark colour of the end of the nose. She is a little dark around the eyes, which is not astonishing after many sleepless nights. Auscultation of the lungs gives only negative results.

Treatment: Vichy water internally, also a little Friedrichshalle water in order to keep the bowels well opened. Tonic regimen: meat, Bordeaux wine, quinine wine. To the extremities aromatic fumigations of benzoin. Four or five times daily, frictions with mint water, with a little ammoniacum added to it. (These frictions were employed for several days, and led each time to a temporary but notable improvement of the local state.) Finally, attempts to re-establish menstruation: twelve dry cups to be applied to the inner surface of the thighs; poultices every night.

The morning after March 30 the pains of the feet became so intolerable that standing was impossible. The patient passed the night in her arm-chair, finding that the heat of the bed and the weight of the coverlets exaggerated the pains. These follow now a decreasing course in the hands, whilst in the feet they go on increasing. There is still a sensation of severe pungent burning, of which the patient cannot give the precise seat or extent. This same day it is observed that the dark colour of the extremities of the fingers is diminished in extent, and at the same time it is more distinctly limited. All around there is a reddish circle with elevation of temperature; this is a beginning of local reaction. When the patient succeeds in sleeping two or three hours her sleep is extremely heavy; on waking she remains ten minutes without knowing where she is. M. Vernois recommends the persons who surround her to wash her face with very cold water as soon as she awakes. This troublesome symptom only lasted two or three days.

April 1.—In the morning there was a painful attack, which lasted twenty-five minutes, and which surpassed in intensity all

that the patient had previously experienced (this attack was the last); it was limited to the feet. During the whole day general irritability carried to the extreme. The patient does not suffer except when the feet are approached. There was fatigue and prostration. In the evening there were some hysterical phenomena; desire to extend the limbs; involuntary crying and frequent emissions of urine; urine was extremely clear with an acid reaction, density of 1022, containing neither sugar nor albumen; true nervous urine.

Local condition: in the hands slaty coloration tending towards green, occupying about the lower third of the last phalanges; it is limited by a very definite sinuous border, behind which there is an areola of intense red with some heat of skin. The coloration of the nails is a little better excepting on the two little fingers, which are still quite black. Aromatic frictions revive these extremities to a slight extent. In the middle of the most diseased part there are small violet patches as big as pin heads, cut off by their colour from the remainder, not disappearing with pressure or friction. These are small eschars completely formed.

April 2.—Almost the same condition. There have been no severe attacks of pain since yesterday. The inflammatory circle of the hands has gained a little in extent. The toes are entirely black; at their base there exists very clearly a red areola similar to that of the hands. On the external border of the foot we see livid marblings extending as high as the heel. Along the outer border of the hands, and along the inner border of the feet, there exists a lichenoid eruption characterised by small red plâques scarcely at all elevated and very close one to the other.

April 3.—There has been no new attack; when at rest there is almost no pain; the patient can assist herself a little in eating. She feels, she says, with the pulp of the fingers as though through a nail. With the right hand the extremity of the thumb is entirely red. The nail of the index finger is rose-coloured. The livid colour of the extremities has become much paler in the three last digits; it increases in extent from the middle to the little finger, of which two-thirds are still affected. The nail of this last digit is entirely black, save the lunula, which begins to pale. Analogous condition of the left hand to a slightly more pronounced degree. In the feet œdema of the two sides,

mounting in the left as high as the malleolus, preserving the impression of the fingers. The nails of the great toes are of a dead white; those of the little toes are rose-coloured; the three middle toes are still more or less black and have violet nails. There is a broad zone of a bright red at the anterior extremity of the plantar surface of the foot. Extensive marblings are marked out along the external margin.

April 4.—On the hands a red-currant colour, limited by a sinuous border, occupies the tips of the thumb and index, which on the preceding days had a slaty colour. In the middle finger only just a few whitish traces of the past condition. The ring finger presents still a moderate amount of greenish white colour. The nail of the little finger is black.

In the feet the three middle toes are still violet in one half of their extent, red beyond. The marblings of the outer border have a better aspect.

The night has been satisfactory. It was observed that the patient was very flushed during sleep. She has not experienced any more pains. She feels still as though through a glove, but the least touch of the extremities causes an extreme irritation; she has tinglings similar to those of chilblains.

April 5.—Consultation, in which Messrs. Nélaton, Vernois, Barth, Hervez de Chégoin took part. These gentlemen are unanimous in recognising a considerable improvement, and prescribe the continuation of the treatment.

April 6.—All the nails of the hands are rosy save that of the little finger. On the feet the black coloration of the three middle toes does not pass beyond the first phalanx. It no longer disappears with pressure. The left foot presents blisters on the dorsal surface of all the toes.

The state of the sensibility now allowing a little more precise examination, we applied a delicate thermometer to the black extremity of the toes, protecting it from the air; it registered 89·6° F. Applied in the same way, and under the same conditions, upon the foot of a healthy person it registered 95° F. We pricked these dark extremities somewhat strongly with the point of a pin. The prick was not perceived, and not a drop of blood issued from it. A prick made on the dorsal surface of a toe gave a little blood. This examined with the microscope presented normal conditions; dimension of red blood corpuscles 0·0066 mm.

The white corpuscles were present to the number of 10 to 12 in the field.

April 7.—The patient has been able to walk. Urine continues abundant.

April 8.—The epidermis of the digital extremities of the hands is reddish brown and parchment-like; on pressing it one feels clearly that it is no longer adherent to the subjacent true skin. On many digits there exist true blisters. The pulp of the little finger has become rosy again, with the exception of two or three millimètres at the tip. The nail is only partially black, and this is a phenomenon of transparency, because the free edge of the nail is of a natural colour. On the two feet there are large blisters. It is worthy of remark that at this period of the disease, that is to say, more than three weeks after the commencement, the nails of the diseased parts have not pushed forwards at all, and have exactly the same length as at the commencement.

April 10.—The right thumb has recovered almost all its sensibility. In the other digits the feeling is blunted, and there is still the sensation of things being felt as though through parchment. Several digits are diminished in size at their extremities and shrivelled; they look as if they had been for a long time compressed by a ligature. The extremity is very much tapered off. On the feet the blisters begin to dry up. The second and third toes are very black; the nails are of a greenish tint. The other toes have lost a little of their dark colour. During the day there were tinglings in the hands. On getting up the patient has much difficulty in walking, especially on the left foot. The œdema of the feet has diminished a little.

April 12.—Extreme excitement; the patient does not feel any actual pains, but sensations like small sudden pricks. The hands to-day feel very numb.

Right hand: desquamation over the thumb and index fingers. On the middle finger a black longitudinal band; this digit, as well as the ring finger, is as though it had been compressed. On the little finger the nail is quite black. All these extremities resemble parchment.

Left hand: here are black patches on all the digits. They are shrivelled as though they had been compressed with a string.

Right foot: little toe entirely clear. Inner half of the fourth dark; the pulp of the two following toes dry and black like coal; on the great toe deep marblings.

Left foot: the three middle toes are as though they had been charred. The great toe is black in its outer half and presents some blisters. Nothing on the fifth. The two feet are still œdematous.

To-day the nose has had at times a violet colour. Some small black points have shown themselves on one buttock. Pains referred to the loins and the lower part of the abdomen.

April 19.—Desquamation is more pronounced. Many blisters have burst.

Hands: the more external the fingers are, the more they desquamate. The index finger is entirely stripped. On the thumb there remains a small patch above the nail. On the three last fingers there are longitudinal lines well marked, dark and shrivelled. Tinglings excessive.

Feet: the skin of the two big toes has become deeper coloured. The third and fourth toes begin to suppurate along the limit of the dead and the living, and exhale a bad smell.

April 27.—In wiping the foot we swept away a broad black scab from the plantar surface of the second toe.

May 7.—On waking, the patient perceived that she had lost a few drops of blood from the genitals. The oozing continued till next day.

May 14.—The catamenia have appeared abundantly enough to make it seem desirable to prescribe a little *sirop de Consoude.*

They are now on the decline. The general condition is excellent. Both indices are entirely stripped. The epidermis desquamates everywhere in broad patches. The patient cuts it off as it desquamates.

On the feet suppuration continues moderately. They exhale a disagreeable odour. The eliminatory process is the most advanced on the fourth left toe. The nail has fallen some time ago, the slough is ready to become detached.

June 1.—The catamenia reappeared and lasted until June 9th. On each foot the great toe presents a broad black swelling, which on the right side is in great part detached. The two following toes present shreds completely detached at the lower part and adhering to the nail by their upper surface; one might call them

bits of coal placed on the ends of the toes. The toes are clubbed. The two last are healthy, with the exception that the fourth has lost its nail. All the fingers are entirely stripped of epidermis; some nails are still brown in part. The two little fingers have the lower half completely black. Pus oozes from under the border of the nail. From this time the greatest possible care was paid to cleanliness. In proportion as the dry scabs became troublesome, and we could touch them without pain, we cut them off in order to render walking easier for the patient. Cicatrisation took place at the same time. The last piece (from the last phalanx of the fourth left toe) fell off on the 27th October, 1860.

The general health continuously improved. Menstruation became regular, the colour became clear, and the patient became fairly stout.

On two or three occasions this young woman again experienced pulsations in the head with a feeling of fainting. One of the last times that this phenomenon occurred (February 28, 1861) I ausculted her; the pulsations of the heart presented great irregularities. The day after (March 1st) they became perfectly normal. Since then her health has been excellent, and there is no sign of any return of similar attacks.

To-day (Jan., 1862) the two feet present an exactly symmetrical aspect. At the extremity of the great toe there is a projecting tubercle upon which the deformed nail rests, and around which the skin is raised and covered with scales. The two succeeding toes present a massive stump, upon which small crusts exist which have never disappeared. There is no trace of nail. Pulse perfectly regular. Pulsations of the heart normal.

A remarkable fact, and which I mention now without offering any explanation of it, was observed in the child born of this woman; three days after its birth we perceived that from time to time the right hand and forearm presented a very marked violet colour, which was not limited, and disappeared afterwards to reappear at a later period without known cause. This continued during the four or five first months of life; otherwise the little child has been always healthy.

The considerable length at which I have reported this case frees me from dwelling upon the details, which were sufficiently unusual for such men as Nélaton, Barth, Vernois, Hervez de

Chégoin to declare that they had never observed anything similar. I content myself with summing up the most striking features:—

1. The condition of the pulse, which, although irregular at different periods of the life of the patient, was always normal whilst the illness lasted.

2. The condition of the heart, which, in spite of functional troubles corresponding to those of the pulse, presented certainly no organic affection, at least so far as could be ascertained by auscultation.

3. The remarkable slowing of the capillary circulation during the painful attacks.

4. The probable influence of amenorrhœa, the return of the catamenia being accompanied by the restoration to health.

5. The disastrous effects observed after a too active counter-irritation.

6. The attack affecting all the extremities successively, which excluded the idea of a cause acting simultaneously upon all the vascular trunks.

7. Finally, the combination at a given moment in the same patient of all the conditions between which I desire to establish the relation from syncope up to confirmed gangrene, and the spontaneous loss of the four extremities of the toes.

This is another fact of the same kind:—

CASE XVI.*—*Dry gangrene of the first phalanges of all the digits of both feet and both hands.*

R. M., of Palermo, aged 34 years, of robust constitution and of bilious temperament, had abandoned himself without restraint to pleasure and debauchery, and had contracted numerous sypyhilitic affections which had been only partly cured. He was obliged to undergo a considerable amount of hard work and exposure, to which he was not accustomed, and in addition, during the months of September and October, to bivouac out during the night in the districts around Palermo. In the month of October he experienced slight pains, accompanied by numbness, in the little finger of the left hand, to which he paid little attention; but in a few hours the toes were affected with the same numbness, without any pain. The patient, attributing

* By Portal, *Archives générales de médecine*, Année 1836, 2e Série, T. xi., p. 223.

these symptoms to a chill, went to bed and took sudorific drinks. The following day a painful sensation was felt, not only in the fingers but also in the toes, and extending up to the ankle. The pains becoming very severe he consulted a doctor, who took the malady for rheumatism, and prescribed mercurial frictions to the inner part of the thighs. Nevertheless the illness made slow progress; the pain was especially severe in the radio-carpal articulations. He consulted other doctors, who, having no hope of curing the illness, asked him to call in a surgeon. Dr. Portal was called to see the patient in the month of November; he recognised a dry gangrene which was ushered in by the above symptoms, with general prostration of strength, without fever; the countenance as well as the whole body was of a deathly pallor; the eyes were fixed, or rolled languidly in their orbits, then were arrested like those of an idiot, or as if the enfeebled mind of the patient had been struck by some terrifying object. The abdomen was hard and tumefied; micturition and defecation were not affected; the ends of the fingers and of the toes from the first to the second phalanx had become as black as coal, as hard as horn, and insensible to touch; the healthy part, which was contiguous to the gangrenous part, was slightly red. Decided as to the nature of the malady, Dr. Portal prescribed stimulating poultices to the hands and feet. He prescribed internally the following mixture: extract of cinchona 2 drachms, assafœtida 12 grains, opium 4 grains, to take in four doses. He prescribed besides 2 ounces of ass's milk every three hours. These orders were only half carried out, which led Dr. Portal to admit the patient to hospital under his care. He continued this local and general treatment during many days, until he perceived at the limit of the gangrenous part that a bright red inflammatory circle was being formed, which indicated that the organism was regaining strength, and that the separation of the dead from the living was taking place. Then not wishing any longer to defer the resection of the phalanges of the fingers and toes, he performed this operation on the 2nd December, using a sharp-edged tenaculum for the toes, and an ordinary saw for the fingers. The wounds were treated at first with dry charpie; subsequently with Galen's cerate (almond oil, wax, and rose water) and styrax ointment. The patient left the hospital perfectly cured at the end of forty-six days.

V. *Cases of symmetrical gangrene, with lesions of the circulatory apparatus, established by autopsy.*

The above completes the list of cases which appear to me clearly to enter into the category with which I am concerned. Before going further, I propose to record three cases more or less analogous to those previously narrated, but followed by autopsy, and in which the lesions found post-mortem seemed up to a certain point to account for the phenomena observed during life. I shall have to discuss subsequently whether these lesions were sufficiently important to play the part in the production of the malady which one would at first be tempted to attribute to them.

The first of these cases has unfortunately little value on account of the obscurity of the pathological description.

CASE XVII.*—*Idiopathic gangrene of the four extremities, resembling gangrenous ergotism.*

A woman aged 46 years, a dressmaker, after a dissipated life, had contracted syphilis, for which she had been treated at the Blockley Hospital. When she presented herself under Dr. Henry's observation the gangrenous affection had gone on for two weeks; it had commenced with a sensation of pricking in the hands and feet. Soon these organs took on a deep sombre colour. Dr. West, who had seen her at first, thought that she had purpura.

The following is the description which Dr. Bernard Henry gave of the condition of the patient when she entrusted herself to his care: general subicteric tint, with a marked expression of anxiety; yellow conjunctivæ and swollen eyelids; intelligence remarkably clear. The hands and forearms for about a third of their length of a lead-like colour, becoming darker towards the digits, which were flexed on the hand, black, dry, and shrivelled in appearance.

The feet and lower thirds of the legs presented the same aspect. The extremity of the nose, and the skin covering the two patellæ, were of the colour of bronze, and appeared as if they had been painted over with a brush. The tongue was dirty, but presented two reddish brown longitudinal patches. Pulse 80,

* By Dr. Bernard Henry, *Gazette médicale*, 1857, p. 323. Translated from the *Medical Examiner* (American), Dec., 1855 to April 1856.

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small and rapid. The diseased extremities presented a glacial cold to the touch, the coloured portions had lost all sensibility, but above the coloured limit they were very sensitive. The cartilages of the ears began to show the same morbid conditions. There was constipation, and the quantity of urine passed was very small.

The woman succumbed two months after her admission to the hospital, in spite of stimulants, opium, nutritious diet, &c.

Post-mortem examination showed engorgement of all the venous system by dark, thick blood, whilst the arterial trunks were almost empty. The femoral and brachial arteries were examined, and presented nothing which differed from the normal appearance, except that they were adherent to the bone, and closed at the line of demarcation. Lungs healthy. The heart showed a tendency to fatty degeneration. The liver large, cirrhotic. The other organs were healthy.

In discussing the nature of the disease in question, Dr. Henry considered that it showed great resemblance, if not complete conformity with gangrenous ergotism, and nevertheless he believed that it was a new affection. Against the view that it was a case of gangrenous ergotism he gives the statement of the patient, who affirmed that she had always had good food, and had never eaten bread of bad quality. In the absence of any other cause Dr. Henry holds that the gangrene declared itself spontaneously as a sequel of the exhaustion of the constitution induced by debauchery.

What a pity that this autopsy should be unintelligible at the very point which interests us! What is meant by arteries normal but adherent to the bone, and closed along the line of demarcation? Was there a clot or only a simple retraction of the vessel on itself?

CASE XVIII.*—*Spontaneous gangrene of the two feet. Death. Autopsy. Contraction of the mitral orifice and narrowness of the arterial system.*

M. Godin showed the arterial system of a woman aged 25 years who had succumbed to a spontaneous gangrene of both feet, brought on without any other cause giving rise to it than an excessive cold experienced during the night of the 25th of December, 1835. This woman had always been thin, and on

* Taken from the *Bulletins de la Société anatomique*, 1836, T. xi., p. 109.

seeing her, one might have believed her much older than she really was. When she died, on one side the gangrene was limited to the foot; on the other it had extended up to the malleoli. At the autopsy the abdomen and the viscera were found perfectly healthy, as well as the lungs; only two or three tubercles of the size of small nuts were found at the apex of the right lung. The heart was remarkable for its small size; it was well formed otherwise. There was considerable contraction of the left auriculo-ventricular orifice from induration of the mitral valve. The aorta at its origin was only 2 inches in circumference, and progressively contracted, so that its circumference was not more than 1 inch below the cœliac axis and superior mesenteric; the iliac arteries were in like manner very small; the femorals were not bigger than the axillary arteries generally are in a subject of the same size; the anterior tibial and the tibio-peroneal trunk were not three-fourths of a line in diameter; finally, the peroneals and posterior tibials traced into the gangrene were about the size of the articulars in a healthy subject. Otherwise these arteries were perfectly permeable, and there was no modification or morbid colour in the interior. The venous system was healthy; there was no œdema.

M. Godin thought that in this subject the efficient cause (cold), which in any other case would not have had such an effect, sufficed to determine the gangrene; the contraction of the left auriculo-ventricular orifice, in consequence of which the blood arrived in the ventricle in small quantity, and consequently also in small quantity into an arterial system already insufficient to nourish suitably the parts to which it was distributed, also contributed to produce the malady.

CASE XIX.*—*Convulsive attacks, spontaneous gangrene of the toes, local asphyxia of the hands, complication of pneumonia. Death. Autopsy. Contraction of the two auriculo-ventricular orifices.*

Abstract.—T., aged 32 years, worker in lace, arrested many times for vagrancy, sent to the Salpêtrière, November 7, 1855, on account of epileptiform attacks. Notable alteration of intelligence, incoherence of ideas.

* By M. Topinard, *Bulletins de la Société anatomique*, 1re Série, T. xxx., p. 528, ann. 1825.

Ulcers on the legs for more than two years of irregular progress; legs warm to the touch, shining, excoriated in some places, and painful.

November 15.—The pains became much more intense; bluish livid points appeared on each side around the toes, and soon afterwards on the dorsal surface of the feet; the legs in their lower two-thirds became cold and œdematous; pulse irregular, small, frequent, perceptible in all the limbs; impulse of the heart strong and extended.

Constipation.

November 23.—Gangrene had increased; shreds of sloughy skin had become detached all in a piece leaving a sanious surface. The patient maintained that her upper as well as her lower limbs were dead; she complained of intolerable pains in them. Around the nails on the dorsal surface of the hand and on the forearm violet marblings were seen.

On the following days the sloughs became more and more limited to the dorsal surface of the feet. The œdema disappeared, but the general condition became aggravated; a comatose condition came on, subcrepitant râles mixed with crepitant gurgling were heard behind at the base of each lung.

November 31.—Death.

Autopsy.—The vessels at the margins of the gangrenous area contain recent clots, but in no part are there to be found free rolled up clots formed manifestly ante-mortem.

The internal surface of the arteries is of an intense red, uniformly distributed, not disappearing with maceration, the more pronounced as one approaches the heart.*

No ossification. Venous system filled with diffluent blood.

Pericardium healthy. The heart is neither dilated nor hypertrophied. Arterial orifices normal. But the two auriculo-ventricular orifices have diminished about three-quarters their normal size by soldering together of the valves; there is a narrow cleft half a centimètre broad, its lips furnished with small excrescences of cartilaginous aspect. Red hepatisation at the base of the left lung.

Without for the moment estimating the value of the cardiac lesions reported by M. Topinard, I will mention only that this

* Upon the small value of redness of the internal coat as a sign of arteritis *vide* Laennec, *Traité de l'Auscultation*, T. ii., p. 606.

explanation did not appear to satisfy the members of the Anatomical Society. M. Broca drew attention to the absence of vascular lesions, and expressed the opinion that in this case the gangrene was related to some unknown cause, perhaps to an alteration of the blood. The epileptic antecedents of the patient ought to enter into account.

VI. *Appendix.—Doubtful Cases.*

The cases which follow present less and less certainty. Nevertheless they are interesting as a group, because they are in a marked degree removed from what occurs in the common cases, and because they may perhaps one day contribute to clear up many obscure points. It is not impossible that we may have here a very advanced form of the malady which occupies our attention.

CASE XX.* — *Gangrene occurring each month in a young woman, aged 23 years, at the extremities of the fingers, ears, nose, &c.*

In 1629, travelling with my brother, Jean Schrader, and Alexander Lak, whilst studying surgery, we found ourselves in a town called Geest, and having entered a hostelry the master, who was called Jean Brandes, made us see his daughter, aged 23 years, who was attacked with the following malady: each month she suffered from severe pains in the extremities of the fingers and of the toes, accompanied by œdematous swelling of the face, feet, and hands; this was followed by sphacelus or mortification of the extremities of those parts in which the pain was first felt, which became pale, dry, insensitive, nevertheless with no bad smell, and with no humour proceeding from them. These gangrenous parts separated each month in small morsels, which preserved their normal form. Whilst informing me more particularly of the circumstances of this illness, the father of the girl showed me a box in which there were more than a hundred of these morsels of dead flesh, which in the space of three years had been thrown off and detached from the extremities of different parts of the body of this girl.

* By Bernard Schrader, *Collection académique partie étrangère*, T. iii., p. 238. *Eph. cur. nat.*, 1773—74.

CASE XXI.*—A young woman of this town, aged 26 years, having been tormented for a long time with an insupportable heat, accompanied by the most severe pain, in the feet and the hands which all remedies failed to quiet, was advised to plunge them many days running into the coldest water which she could find, renewing it from one moment to another (because it became hot almost as promptly as if it had been over the fire). She continued this manœuvre during so long a time that gangrene supervened on the parts where she felt the heat and pain, and she lost all the digits of the toes and many of the extremities of the fingers. They succeeded in arresting the progress of the gangrene excepting in the right foot, which it was necessary to remove, but the patient up to the present time has not been willing to have the operation performed.

Is it not probable that in this case the intolerable pains which appeared at the outset were the initial pains of the gangrene, and that the influence of the cold water only acted as an adjuvant cause?

CASE XXII.†—William Chandler, aged 3 years and 7 months. Seen first on January 29, 1839. He was the son of a bargeman who earned about a pound a week. The mother was delicate. One child had died aged 2 months, another was weakly. The general food of the family had been bread and potatoes, with meat two or three times weekly. William Chandler had been weakly from birth but free from any evident disease, and he had run alone at 2 years old. When first seen asleep his cheeks were pale but plump. On removal from the cradle his cheeks became rather purple, and a dark livid spot appeared on his nose, which I was informed was the scar of a former slough, but it appeared the precursor of a second gangrenous spot. His right forearm was gone, having been partially amputated by nature at the articulation of the radius, though the ulna had been divided lower down. The slough had extended above the elbow joint, where nature seemed to be making a second attempt at amputation from the pale line of ulceration between the living and dead portions

* By Christophle Hertius, of Nassau, *Ephemerides des curieux de la Nature*, 1685.

† By Mr. Solly, *Med. Chir. Trans.*, vol. xxii., p. 258, 1839, and vol. xxiv., p. 237, 1840.

of the limb. The whole of the left forearm and about half of the upper arms were in a state of dry gangrene, but there was a distinct line of separation in the upper arm.

The left foot was completely removed just above the ankle joint, between the epiphysis and the shaft of the tibia and fibula, leaving the extremities of the bone exposed, the soft parts presenting a surface healthy and granulating in one part but sloughy in another. On the right foot the second and third toes had been removed, the stumps having a healthy cicatrix; but on the calf and knee there were livid spots. The pulse in the carotids was 140, feeble and easily arrested.

The action of the heart was more feeble than natural, but unaccompanied by any unnatural sound.

The intelligence was good and the child quiet, but complained much of feeling cold unless close to the fire. From the mother's account I learned that the disease commenced at the latter end of last August, both the feet becoming of a blackish purple colour; that hot flannels relieved them only for a short time. Sloughs began about the beginning of September on the right leg, first above the heel. These sloughs separated. The sore healed in about a month; that on the left leg never healed but gradually extended over the foot; a line of demarcation was ultimately set up. Amputation gradually took place, and the limb was entirely removed by December 20th.

The disease began in the left upper arm about the middle of November on the dorsal surface of the wrist. It followed on the right about a fortnight afterwards, commencing below the ulna, and the ulna was divided on the 18th of January. But nature apparently not being able to effect the amputation perfectly in that spot, recommenced above it. The radius, together with the hand, were separated at the elbow joint on the 26th January. The date of the amputation of the two toes on the right foot could not be ascertained.

From a surgeon, under whose charge the patient had been at the outset, Mr. Solly learned that when the child was seen at the beginning of September there were large vesicles on the right foot and forearm, containing a dark livid fluid. Warm fomentations were ordered, and stimulants internally. The vesicles broke and left a gangrenous surface, which progressed up to the condition previously described. By the end of April

the three stumps had nearly healed and the child's health improved, and he was suffering much less pain.

The sequel of the case published in the 23rd volume records that on July 21st the dry gangrene recommenced in all four extremities, or rather in the remaining parts. The upper stumps were swollen and livid, and indicated a line of separation parallel with each acromion process, and almost circular. The right leg was in the same state up to the middle of the calf, and there was a large patch over the patella and front of the knee. The left leg from the point of the stump to the middle of the thigh was similarly affected. On the right cheek there was a superficial eschar. There was an abundant miliary eruption diffused over the whole body, and considerable feverishness. He was languid and restless, with a clean but dry tongue and feeble and rapid pulse.

August 9.—The soft parts of the left lower extremity below the middle of the thigh came off on the 6th inst. in a dead and shapeless state, leaving the shaft of the os femoris bare, but deprived of its condyles. There is, however, a healthy granulating surface on this fresh stump, affording a free purulent discharge. The right foot is nearly detached just above the ankle joint. On the shoulders the disease has apparently stopped suddenly, as they present merely superficial crusts of gangrene, shortly about to be thrown off. A similar patch has exfoliated from the front of the right knee and is succeeded by a pretty healthy wound.

September 8.—The child was found dead in his cradle in the morning.

Post-mortem examination by Mr. Bury showed great emaciation, and the skin contained the remains of the miliary eruption in the form of small dried scabs. There was a subcutaneous hæmorrhage on the left cheek nearly equal to the size of a shilling. A like spot was visible on the epigastrium. The stumps of the arms were conical and nearly healed, their apices being enclosed in a small dry crust. The left thigh presented in its middle a small granular surface surrounding the bone, by no means indicating want of vital action, beyond which the shaft of the bone itself projected undiminished in size or length. In the calf of the right leg there was the same kind of amputation observable, with the tibia and fibula protruding; but the wound

was dark and the integuments above were of a deep modena hue, showing that mortification was here re-established and spreading. The wound over the knee was contracted but purple.

Both lungs were remarkably pale. The pericardium contained a small quantity of clear serum. The heart, beyond some pallor of the muscular walls, showed no structural change. There was dark coagulum in all the cavities, and in all the vessels. Both femoral arteries were remarkably shrunk, being obviously less in calibre than their veins, very pale, and were not patulous on division with the knife. The liver was bloodless, though otherwise healthy, and this may likewise be said of the other abdominal organs.

Mr. Solly himself dissected the sympathetic in the neck, chest, and abdomen, but the dissection revealed nothing abnormal. The arteries were traced, but nothing abnormal in structure or distribution was found. He thought they might have been rather smaller than natural, but even this was doubtful.

CASE XXIII.*—*Pains in the Four Extremities; appearance of gangrenous patches on different parts of the body; mortification of the two hands. Many relapses. Cure.*

Abstract.—The case was that of a little girl, aged 8 years, who complained in January, 1803, of very acute pains in all the limbs, and especially in the lower extremities. There was fever, wasting, and appearance on all the surface of the body, the head excepted, of brown patches, which disappeared in the month of April of the same year. Good health up to January, 1804. Then the fever and the brown patches reappeared, and in addition there occurred pains in all the limbs. The last phalanges of the digits of the left hand became black, and in a short time the whole of this hand was affected with gangrene. The malady continued its ravages up to the following June; the left hand kept attached to the forearm only by a small shred of skin and the tendon of one of the flexors. The last phalanx of the thumb, of the ring finger, and little finger of the right hand were on the point of separating, and two phalanges of the right foot had fallen off. There were many sloughs on the shoulders, on the lumbar region, and on the posterior part

* By Bocquet, *Journal de Corvisart*, T. xvi., p. 283, ann. 1808. Extrait du Bulletin publié par le Comité Central de la Société de médecine du département de l'Eure.

of the right thigh. Slight fever and good appetite. M. Bocquet ended by removing the hand, covering the wounds with pledgets steeped with storax surrounding the limbs, with compresses steeped in ammonia and camphor lotion, and prescribing quinine wine internally in strong doses. At the end of a fortnight the feet were in very good condition, and all the gangrenous phalanges were detached. The same treatment was continued; three weeks sufficed to cicatrise all the wounds, but the left radius and ulna, which had been denuded, only exfoliated in the month of August. There was a return to health and good nutrition.

In the early days of January, 1805, the symptoms returned and continued up to the month of August, but there were no sloughs. In the month of January, 1806, the same phenomena reappeared for the fourth time. They only lasted a few days. (Treatment as above.) The skin regained its natural colour.

January 23, 1807.—There was no symptom to announce the return of this terrible malady.

CASE XXIV.*—M. Molin saw a young woman affected with a gangrene, which seized one foot at first and led to its separation from the leg. The other foot then became gangrenous and separated like the first. The patient lost successively many fingers, and then the gangrene proceeded no further. This young woman then became well again, and even stout.

CASE XXV.†—The Academy saw a young woman, called Anne P., of Moustier Saint Jean, who was nearly 21 years old, and who when she was 7 years old, after an ordinary fever, had both hands and forearms wither away up to the commencement of the elbow, so that she had only two stumps left. She brought her hands in her pocket to the assembly, and drew them forth with one of her stumps, which she used adroitly; they were black and dry like the hands of a little mummy.

It would have been well in concluding this narrative of cases to demonstrate that the connection between them rests upon true

* By M. Molin, *Journal de Corvisart*, T. xvi., p. 288, ann. 1808. Extrait du Bulletin publié par le Comité Central de la Société de médecine du département de l'Eure.

† *Histoire de l'Académie des Sciences*, ann. 1703, p. 41. Might this be a case of typhoid gangrene?

analogies, and that it is not the result of an artificial arrangement. But I could not do this without continual repetitions of observations. The care which I have taken to classify the cases as much as possible in order of gravity, and to distinguish the principal groups, will suffice I hope to indicate their connection and reciprocal affinities and permit me now to make a general summary of the whole subject.

CHAPTER III.

PATHOLOGICAL HISTORY OF LOCAL ASPHYXIA AND OF SYMMETRICAL GANGRENE OF THE EXTREMITIES.

I PROPOSE in this chapter to give a general description of the affection of which I have hitherto presented only isolated examples. One word at first upon the name by which I propose to designate it. The term local asphyxia is not new; it has had scientific circulation since Boyer's time, and is based upon real analogies. With regard to the variety of gangrene which appeared to me capable of resulting from it as the more advanced expression of a similar morbid state I have for a long time sought a distinctive and special character. The absence of arterial obliteration has only a negative value, and also applies to diabetic gangrene. In examining closely the preceding cases I have been struck with the remarkable tendency of the mortification to affect symmetrically similar extremities; thus it is the two hands, or the two feet, or all four at a time, sometimes the nose, composed, like all the median organs, of two equal halves; they are, in one word, similar parts which become affected together in the very great majority of cases.

Further, I have recorded cases in which the localisation of the pathological process to the fingers or to the toes has taken place under the same form and with an equal intensity in exactly corresponding parts. Thus in Case XIII. on each side it was the fourth toe which presented the most advanced lesion; then came the big toe, then the third, then the fifth; finally, the second was almost healthy. In Case XV. the similitude was perhaps still more complete, because it existed at the same time in the hands and the feet. On examining this patient long after her recovery I was struck with the remarkable similarity on the two sides, even of the stumps and cicatrices which had been left after the separation of the sloughs on the two sides. These are, it is true, the most trenchant cases, and those which

may serve as types for the description. Some deviate from the type more or less; the morbid results are produced somewhat irregularly, or to an unequal depth, on the two sides. But the tendency of gangrene to localise itself at the same time to the right and left halves of the body is not the less pronounced, and would suffice, I think, to justify the title of symmetrical gangrene, which I give as a simple statement of fact, and as having the advantage of not prejudging the nature of the malady.

I come now to the exposition of the symptoms, premising that there is no general description which can replace the reading of the recorded observations.

Symptoms.

In order to introduce order into the symptomatology and to avoid confounding together conditions very different, in their gravity, I shall describe first syncope and local asphyxia, and afterwards symmetrical gangrene of the extremities.

In its simplest form, local syncope is a condition perfectly compatible with health. Persons who are attacked with it, and who are ordinarily females, see under the least stimulus, sometimes without appreciable cause, one or many fingers become pale and cold all at once; in many cases it is the same finger which is always first attacked; the others become dead successively and in the same order. It is the phenomenon known under the name of the "dead finger." The attack is indolent, the duration varies from a few minutes to many hours. The determining cause is often the impression of cold; but that which is only commonly produced under the influence of the most severe cold, appears in the subjects of whom I speak on the occasion of the least lowering of temperature; sometimes even a simple mental emotion is enough. It would appear that the same cause which acts upon the capillaries of the face, and brings the red colour to the face, may in other circumstances act specially on the capillaries of the extremities; the skin of the affected parts assumes a dead white or sometimes a yellow colour; it appears completely exsanguine. The cutaneous sensibility becomes blunted, then annihilated; the fingers become like foreign bodies to the subject. They can be pinched and pricked with impunity; they may entirely lose the sense of contact and

yet be able to distinguish heat and cold. Their temperature is notably lowered; this can be easily ascertained by touching them. It was established in one case that the temperature remained constantly one degree R. above that of the surrounding air. Ought the loss of movement in these cases to be attributed to a momentary paralysis of the flexor and extensor muscles? This is hardly possible if one considers that this syncopal state is often limited to a single digit, whilst a single muscle gives rise to many tendinous insertions. It is more reasonable to admit that the diseased part no longer transmitting sensation to the brain, the brain itself loses temporarily, for want of excitant, the power of determining movements. In rare cases the secretions are affected and the dead finger becomes covered with a cold sweat. The slight importance of this local abolition of the circulation is probably due to the fact that it is so transient. The fingers are not the sole subjects of the affection, and if they appear to be more frequently attacked it is solely because they are of more immediate need for the usages of life than the toes. The attack is followed by a period of reaction, which is often very painful, and which gives place to a sensation quite analogous to that of being benumbed by cold.

We must not confound this condition with the numbness which succeeds the concussion or compression of a nerve. In the latter case it is the sensibility and motility which are primarily attacked, the circulation remaining intact; it is precisely the reverse which occurs in local syncope. When this, in place of affecting one or many digits, occupies the whole of a limb, then the circulatory troubles which one was forced to admit in some sort by induction become very evident.

In Case III. there was noted an excessive feebleness of the pulse at the moment of the commencement of the attack, which might have suggested some arterial obstruction if the increase of the pulsations during the intermissions had not appeared to negative this supposition.

In the more pronounced cases, those in which the asphyxial phenomena predominate, the pallor of the extremities is replaced by a cyanotic colour. This colour offers many different shades. Sometimes it is of a bluish white; it seems as though the skin had acquired a greater transparence than natural, so as to allow the subjacent tissues to be perceived; sometimes it is violet or

slate-coloured, even becoming black, quite comparable to that which a slight blot of ink produces on the skin. When one presses on the parts thus altered in colour, the patch of dead white produced by pressure, in place of disappearing instantly, as happens to a healthy extremity, takes a considerable time before recovering the colour of the neighbouring parts, which denotes an excessive slowness of the capillary circulation.

Habitually to this is added a little swelling in the neighbourhood. Very frequently also we see marked out up to a variable height livid venous marblings and which are very like those produced along the legs and thighs of persons who make use of foot-warmers. Pain is almost a constant phenomenon, it may be sufficiently sharp to draw forth cries from the patients; to a painful numbness there succeeds a sensation of burning and shooting which increases on pressure. Meanwhile the cutaneous anæsthesia is complete, and interferes with the prehension of small objects. The period of reaction is accompanied by irritating tingling sensations, which the patients compare to tingling from cold, or to the stinging of nettles.

Then less livid patches appear on the cyanosed parts; they extend and join one another, at the same time a vermilion colour shows itself at the margin; little by little it gains ground, chasing before it the bronzed colour which persists longest in the parts where it commenced, that is, in the most peripheral portions. Finally, a patch of deep red is formed on the extremities of the fingers. This patch gives place to the normal pink colour, and then the skin is found to have entirely returned to the primitive condition.

This condition presents with cyanosis properly so-called analogies upon which there is no need to insist; the anatomical fact is the same—the presence of venous blood in the capillary system. Nevertheless there are important differences. I have never observed in local asphyxia the blue colour of the lips which is constant in cyanosis. But it is also important to note from the point of view of symptoms that cyanosis is related in the immense majority of cases to an organic lesion (persistence of the ductus arteriosus, &c.), the cause being permanent, the effect is so also; it is increased under the influence of an effort; there are no pains, there are no intermissions, although this

obtains in local asphyxia.* Another difference is drawn from the modifications of nutrition which the parts at length undergo. In cyanosis the ungual phalanges take almost constantly the clubbed shape, that shape wrongly attributed by some physicians exclusively to pulmonary phthisis, which is designated by the name of the hippocratic nail. In local asphyxia there is nothing similar to this. The only modification which can occur consists in an excessive predominance of the cellulo-adipose system leading to an exaggerated softness, a kind of false œdema of the extremities; it seems as if this were somewhat analogous to that accumulation of fat which is so frequent in all the organs which perform their functions incompletely. I could not without falling into common-places describe here the general symptoms which belong to local asphyxia of the extremities, they are often absolutely nil. A little breathlessness, muscular feebleness, signs of chloro-hysteria, which have otherwise nothing special; that is all that I should have to say about them. I hasten now to the symptoms of symmetrical grangrene properly so called.

III. The commencement takes place in different ways. In one case the extremities become pale, exsanguine, and then take on a lilac tint; at the same time tinglings or shooting pains occur. These are bearable at first, and accompanied by the sensation of numbness, but are soon replaced by a burning heat, which cold water calms for a time, but this improvement is only momentary; after changes of colour which are impossible to describe, the ends of the fingers take on a violet colour which becomes more and more pronounced, and in which the nails participate; on touching these parts they are found to be icy cold. In another case it is a livid redness which appears first. The patients believe ordinarily that they have chilblains, the more so that they are subject to them; but at the end of a few days the itchings to which they paid no attention become pains of which the severity goes on exasperating and no longer permits of any doubt.

From this epoch the livid marblings show themselves in the neighbourhood of the affected parts along the digits, over the course of the collateral arteries, and rise sometimes to a great

* It is to local asphyxia that Boiseau gave the *bizarre* name of uterine cyanosis, basing it solely on the undoubted influence of suppression of the menses in certain cases. He has reported two examples, *vide* "Mémoire sur la cyanose cholerique, *Journal hebdomadaire*, vol. ix., p. 277, 1832.

height over the corresponding limbs. Arrived at this point the lesion becomes more pronounced according to different modes.

Sometimes the digits become entirely black and insensible; small phlyctenulæ appear upon one digit (particularly the little finger), then on another, always at the extremity. This phlyctenula develops, fills with seropurulent liquid, breaks and leaves the derma naked.

The small excoriation which results from it persists some days. To see this lividity, this glacial cold, one would believe that the grangrene was about to extend more and more; but the malady recedes, the parts become reanimated, the small ulcer cicatrises and contracts, and there results a kind of conical tubercle immediately subjacent to the nail. This recovery is only temporary. Soon we see the same series of phenomena recommence either on the same digit or on another, and I have seen this state of things renew itself during two years with intervals of passing remission. At an advanced epoch on the pulp of all the digits a great number of small, white, depressed, very hard cicatrices is seen, which are, so to speak, the stigmata left after the malady, and which prove that it is not arrested by the epidermis, but that the most superficial layer of the true skin has been attacked. At a given moment all the nails may fall simultaneously. This progress of the malady is not incompatible with the formation of veritable sloughs, especially on the little finger. But that which strikes one most is the slender form which the ends of the digits take, the hardness of their tissue, and their shrivelled aspect.

It may happen that this parchment-like appearance may supervene without having been preceded by the formation of blisters. The skin takes on a drab colour, it seems thinned, dried up, shrivelled, and there results from it a conical form to the finger. One could compare it to nothing better than to the state of things which would have ensued if one had violently squeezed the finger in a chain band, and if it had retained the form impressed upon it thereby. Soon desquamation occurs, and thickened pellicles of wooden hardness are raised up in shreds. There is a form allied to this which I have particularly observed in children. It affects specially the feet. The blisters instead of breaking dry up at the end of a few days by resorption of the liquid, become dark, and are detached in layers; the

subjacent skin is found rosy and smooth. On examining it attentively it is seen that the papillæ have been more or less eroded, and that they present at the maximum point of the lesion a pale violet colour; the skin soon recovers its normal appearance. The whole process takes about a fortnight for completion. If the gangrene at the very outset appears in all its intensity there are no phlyctenulæ, the tendency to mummification becomes manifest, the nail becomes quite black, an entire phalanx takes on a more or less dark colour, and rapidly becomes as dark as charcoal. One might believe then in a profound alteration. But at the end of a few days an inflammatory circle appears at the base of the toe. It becomes more and more pronounced as it approaches the extremity. A thick viscous liquid similar to plastic lymph oozes out of the circumference, and becomes hardened into brownish crusts. Then a true suppuration of healthy character appears at the limit of the disease and under the free border of the nail. The slough becomes mobile, detaches itself, and on withdrawing it we find that it is 1 or 2 millimetres thick; on its surface the papillæ are seen neatly marked out; the deep aspect is soft and tomentose. The remaining living parts are rough, with fleshy granulations which soon cicatrise. It is in this form that I have seen a slough form on the tip of the coccyx, and in another case I have seen brown patches appear symmetrically on the two heels, then disappear by exfoliation.

Finally, in the most pronounced cases all the forms already prescribed present themselves in different degrees on the fingers and toes—viz., the parchment-like condition, with tapering of the ends of the digits, the livid marblings along the track of the superficial veins, the bullæ, &c. These last, I repeat, are formed at the expense not only of the epithelial layer, but of a part of the derma itself. In the parts which are most attacked there is a real carbonisation, which terminates at length in the fall of a third or a half of the ungual phalanx. The whole is accompanied by a very slight œdema of the lower part of the limb. If the nail has not been attacked at its root, a singular thing happens—viz., that the eliminatory circle, becoming more and more hollowed out, the slough ends by detaching itself along the whole of its circumference, except at its upper part, where it remains adherent to the nail. This continuing its growth forwards from

the base, there arrives a moment when the slough is found separated from the living parts by a groove of a few millimetres' width. Cicatrisation takes place proportionally, and to remove the slough it is only necessary to cut through along the edge of the growing nail. Nevertheless the growth of the nails has not been continued; it is completely suspended, and their length remains stationary during all the time that the great pains of mortification last.

Then they recommence to grow, and present at their surface a transverse depression, which indicates thus the period of arrest in their nutrition.

The black colour which they present is a simple effect of transparence; at a later period it is replaced by a greenish colour. Some may fall entirely, others, not finding any further support at their extremity, curve round more or less irregularly, and remain permanently deformed.

I have no need to insist on the lowering of temperature which accompanies the production of gangrene in these cases, as in all others. I will only mention that I have noted at the same time a slight increase of heat over the wrists and on the palms. Since I have made this observation M. Broca has generalised the fact, whilst showing that in senile gangrene there is always exaggeration of heat in the upper part of the diseased limb; he thinks that this phenomenon is due to a supplementary capillary circulation.*

The nose and the external ears are sometimes more or less attacked; but I am not aware that in these situations complete mortification has been observed. The lobule and the alæ nasi present, it is true, a black colour, livid marblings extend to the cheek, but this coloration disappears on pressure, to reappear subsequently. The parts become reanimated little by little, without even passing through the period of desquamation.

IV. In the description of general symptoms we must carefully distinguish those which belong strictly to the malady which now concerns us, from those which are allied either to an antecedent malady or to a concomitant diathetic state.

The symptom which first attracts attention is pain. This is sometimes the primary phenomenon, and generally it rapidly takes on a truly frightful intensity; it is not limited to the

* *Comptes rendus de la Société de Chirurgie*, 1861.

affected extremities, it radiates to every limb; it is a sensation of burning and tearing; it comes on in paroxysms, and it is remarkable that these painful exasperations coincide with a manifest increase of the cyanotic tint. I have seen it give rise to howls of pain in persons habitually quiet and patient; bent double, sitting up in bed, one sees the unfortunate creatures pass all their time, seeking in vain a position of relief, or in rubbing alternately one or other of their affected extremities, uttering a continuous groan, which is only interrupted by piercing cries. Even in the moments when there occurs a little calm the feet and hands remain in a state of irritability, such that the patients conjure you not to approach them. We have seen in Case VIII. each painful exacerbation give place to veritable convulsive attacks. At a later period aphonia, partial paralyses, &c., supervened. But this woman was eminently hysterical, subsequently she attempted to poison herself with opium; there were, therefore many exceptional circumstances in her case which we cannot consider as typical.

These are doubtless very distressing symptoms; the remarkable feature is the almost complete integrity of the principal functions, which is observed at the same time. The patients preserve their habitual aspect, and it is extraordinary to see the feet and hands becoming gangrenous, whilst the nose is almost entirely black in the midst of a face fresh and vermilion-coloured. Respiration goes on freely, the appetite is preserved, the tongue is clean, the digestion goes on well; there is sometimes a little constipation; the urine, rarely diminished, is more often abundant, pale, and limpid, presenting in one word the characters of nervous urine. The intelligence remains quite clear during the attack, but when the oppression caused by the suffering leads to a little drowsiness, it may happen that the sleep is heavy and the face red and congested. On waking, the patient knows no longer where he is; he has lost the notion of the time, seems foreign to all that surrounds him, and remains a considerable time in a state of profound hebetude. It is of some importance to rouse the patient promptly from this condition, because whatever may be the cause of it we have reason to fear, on the part of the brain, a morbid process, analogous to that which affects the periphery. It is wise to rouse the patient, by throwing cold water on his face.

The most important symptoms to note are those which the circulatory apparatus presents; they are sometimes absolutely nil. The pulse never ceases to be perceptible in the arteries of the affected limbs, but it may present remarkable alterations. As to frequency: there may be at the time of the attack a little rapidity of the pulse, which never exceeds 100 a minute, and which is not accompanied by febrile heat of skin.

As to intensity: although ordinarily the pulse is full, it may become small, thin, and compressible; but this is the exception. With regard to alterations of rhythm, I ought to draw a distinction. Intermissions, irregularities more or less pronounced may show themselves at an epoch which is remote from that of the attacks.

In Case XV. this symptom had been noted two days after the confinement, consequently two-and-a-half months before the appearance of the signs of gangrene; it was observed again nearly a year after the cessation of the attacks; we may consider it as purely nervous; it is, however, certain that it was not present when looked for at any time during the continuance of the malady. On the other hand, in Case XII., these irregularities of pulse have appeared with the commencement of the phenomena of mortification. Not only was there a retardation in the arterial pulsations from time to time, but when the radial and dorsalis pedis were examined simultaneously, at times a perceptible pulsation was felt in the first of these two arteries, and none in the second; at other times, but more rarely, the pulsation was more feeble in the radial than in the dorsalis pedis, but it did not vanish entirely, as in the other case. In the great majority of cases the pulse continued regular throughout. With regard to the venous system, I have already noted the livid marblings corresponding to the course of the subcutaneous veins, also a slight œdema, indicating a retardation of the return circulation, but nothing which would make one suppose that there was a permanent obstacle to the course of the venous blood.

As to the heart, sometimes palpitations have been present which were evidently nervous, and in some cases a slight murmur, but so soft as to exclude the idea of a valvular lesion. It is unnecessary to state that in the case of intermissions of the pulse there were corresponding intermissions of the heart's beats, but it is important to note that these functional troubles are

eminently fugitive, and disappear as they come without any assignable cause.

To omit nothing, and although quite convinced that it is only a fortuitous coincidence, I will add that twice I have observed a phlegmon of the neck, having for its point of departure the glands situated under the sternomastoid, and presenting the aspect and progress of an ordinary acute abscess.

Progress, Duration, and Termination.

V. The malady may follow a continuous course, or be prolonged over a considerable time with periods of intermission. There is a relation to be established between the acute form and the gravity of the observed symptoms. In a general way one may say that the most profound gangrenes, those which go the length of causing the fall of many ends of fingers and toes, are also those which present most regularity in their development. We can then distinguish three periods.

1. An insidious period of invasion, during which the symptoms of local asphyxia predominate.* We might believe at first that the whole process would be limited to this; and it is only when gangrene is imminent that we are undeceived. This period, which may be only a few days, never goes beyond a month.

2. A period during which the attention is especially directed to the painful crisis coming on in paroxysms; sometimes each attack is terminated by an abundant emission of urine. This period lasts about ten days; at the end of that time the gangrene is limited and complete.

3. A period of elimination. The duration is very variable, and depends much on the activity of nutrition in different subjects, and the depth of the lesions.

The most general statement that can be made is that it is never less than twenty days, and never more than ten months; but these two terms are exceptional, and ordinarily the duration is from three to four months.

As to the order of appearance of gangrene in the different

* This is not absolute. Thus in Cases XX., XXII., and XXIII. the gangrenous process led to very grave mutilations, and nevertheless had a chronic course; but these facts, which it was desirable to draw attention to, by way of information, are too obscure to justify their inclusion in the general description.

extremities I have noted nothing constant. It is sometimes the hands, sometimes the feet, which become first affected. Sometimes the local asphyxia shows itself at the same time in the four limbs, then it leaves the upper limbs and runs its course up to gangrene in the lower limbs.

The termination even in this grave form of the malady is for the most part favourable. The sloughs detach themselves slowly. Cicatrisation takes place *pari passu* under the dead parts. But the cicatrix remains a considerable time before it is quite complete, and sometimes during more than a year crusts are formed which successively drop off. The chronic form with remission belongs more specially to the benign cases. Here the commencement is ordinarily more or less sudden; the malady following immediately on an emotional disturbance, or on a menstrual suppression, arrives at its full intensity from the very outset.

In these cases we must distinguish the general progress of the malady, and that of each attack.

Many of the patients whose history I have recorded have been traced for two or three years. During this period we have observed three, four, and five recrudescences or attacks, some of which have lasted many months; each attack was in certain cases brought on by the return of the same accidental cause which had determined the first appearance of the illness. The attack may present the continuous type (this is the rarest form); more often it is of the remittent type, or even there is a well-marked periodical intermission; this is then the quotidian type. Each time the commencement takes place at the same point, the index or little finger for example, then the affection invades successively the neighbouring parts. This is especially marked in cases of local asphyxia pure and simple. When the malady has taken, so to speak, right of domicile, a kind of tolerance is produced; the attacks are less grave, but the extremities remain habitually in a state of cold and torpor. One might say there is a permanently benumbed condition; and this state of things may last up to death, which, however, does not appear to have been directly caused in these cases by the lesion of the extremities.

Diagnosis.

VI. The diagnosis of the affection is generally easy. Nevertheless, especially at the outset, it is well to take precaution against several causes of error.

The phenomenon of "dead finger" is too well known by everybody for it to be necessary for me to delay in discussing it. The affection might be confounded with the state of habitual pallor which the extremities so often present in chlorotic females. But the preservation of movement and of sensibility in the latter case, and especially the persistence of the anæmic state, joined to the general trouble, of which it is only the expression, would suffice to remove all difficulties. Is it possible to establish a diagnosis between local asphyxia and frost bite? The phenomena are so similar that in truth it is not a simple analogy that they present to us, it is a perfect identity. But there is this important difference, that frost bite has a constant and perfectly known cause—the impression from excessive cold—whilst syncope and local asphyxia occur under the influence of an insignificant lowering of temperature, or even in the absence of this adjuvant circumstance.

I have already indicated some of the signs which separate congenital cyanosis from local asphyxia; in one clubbing of the nails; in the other the tapering appearance of the last phalanges; and in rarer cases fatty increase at the extremities. I have added that in the morbus cœruleus the deep tint of the fingers and of the toes is only the exaggeration of what occurs over the whole surface of the body. The ground colour is always more or less blue; this colour, which increases under the influence of an effort, never entirely disappears. The breath is always short and difficult, there are frequent faintings. We must bring into proximity with congenital cyanosis that which results accidentally from organic affections of the heart; but in this case the signs furnished by the general condition and by auscultation are so manifest that mistake would be inexcusable.

Diagnosis may offer more difficulties when pain precedes by a longer or shorter interval the appearance of a livid colour of the extremities. We have seen in one case of this kind (X.) the malady taken for rheumatism by a distinguished surgeon, and treated for that disease; in this case the pain was situated not

in the extremities, which subsequently mortified, but in the tibio-tarsal joint and in that of the wrist. It will suffice to recall that in acute articular rheumatism the pain of the joints is almost always accompanied by redness, tumefaction, synovial effusion, and fever, and that in the disease in question nothing of this kind occurs. Sometimes in place of this pseudo-rheumatic appearance the malady assumes a neuralgic form. In this case, and before the appearance of the morbid colour of the skin, the error would be an easy one to commit, especially if there were well-marked periodicity. Yet still if we must acknowledge that local asphyxia is a rare malady, do we know on the other hand many neuralgias which affect simultaneously the four limbs?

This would in itself be a proper reason for suggesting a warning. One may further remember that neuralgic pains follow the known course of a nerve, that they are increased by pressure on special points, whilst the initial pain of gangrene has no precise seat, and extends often from a very limited point to spread vaguely round the shoulder or the thigh. By reason of these characters confusion would be much more easy with the osteoscopic pains of tertiary syphilis, all the more that we have had some cases in which the suffering was exaggerated during the night. Syphilis is so common a malady that it is better to suspect it where it does not exist than to fall into the opposite error; it will be therefore always wise to examine patients from this point of view.

When either primarily or after a prodromal period the imminence of gangrene is indicated by a change of colour of the extremities we may have to do with one of the two forms upon which I have already so much insisted: either the excessive pallor with cooling and insensibility, or the livid tint of the skin passing on to blue then to black. In the first case the numbness and the muscular anæsthesia might lead one to believe that there was a partial paralysis by section or alteration of structure of a nerve. An attentive examination will prevent our being deceived. But there is another form of partial paralysis more insidious, and which is but little known, although it is not very rare to meet with it in practice, viz., the essential paralysis which is observed especially in infants.* We know

* *Vide* Rilliet et Barthez, *Maladies des Enfants*, 2e Edit., T. ii., p. 545.

that some cases of clubbed foot have no other origin than in partial paralysis. Adult life is not exempt from this form of partial paralysis, and I had last year the opportunity of observing two cases of this kind under the care of M. Vernois, once in the leg, the other time in the forearm. This paralysis occurs suddenly, so much so that patients can indicate the hour and the minute when they felt themselves attacked. It is accompanied by anæsthesia and absolute akinesis, and ordinarily disappears in a few days. It is sufficient to be forewarned. Moreover there is absence of discoloration of the skin, the deprivation of sensation and of movement is limited to a single limb, and is distinguished thereby from local gangrenous syncope, of which the symmetry is the principal character.

If, on the contrary, the gangrene commences by a diffuse livid colour it is almost always confounded at the commencement with chilblains, and this error on the part of the patients is also easily made by the doctor; moreover the itching and painful smarting are naturally referred to a very common affection. Whatever may be the true nature of chilblains (and it is very probable that they have some relation with gangrene of the skin), since in every case the cause is very different, it would be very important from the beginning to establish a diagnosis. Unfortunately this is often very difficult. I will say only, distrust chilblains which form simultaneously on many digits of both feet and both hands in a season and at a temperature when they are not habitual.

Gangrene once confirmed, the diagnosis is obvious. There only remains further to determine with what variety of gangrene we have to do. As this touches on a point of doctrine I must refer the reader to the article on the nature of the disease. For the present I content myself with summing up the diagnosis in the following propositions:—

Symmetrical gangrene of the extremities approaches the so-called senile gangrene by virtue of its mummy-like form. It differs from senile gangrene in (1) the seat of its lesions. Senile gangrene affects, in the immense majority of cases, a single limb, and almost always a lower limb. Symmetrical gangrene, as the word indicates, occupies simultaneously two similar extremities, as well the upper as the lower, or all four at the same time, and on these extremities it tends to occupy parts similarly situated.

(2) By extent. Senile gangrene never occupies less than a single toe, and very frequently extends up to the malleoli and beyond. Symmetrical gangrene is mostly limited to the skin, or to a very small extent beyond, as, for example, to the extremity of the ungual phalanx.

(3) By its progress. Senile gangrene is ordinarily serpiginous; it commences at a single point, radiating thence without regularity. Symmetrical gangrene affects all at once many points at the same time, which become sphacelated in an isolated way. In this variety alone the nose and the ears may present unequivocal signs of local asphyxia.

(4) By the state of the vessel. In senile gangrene one generally feels along the course of the artery a hard cord which rolls under the finger, and the arterial pulsations are diminished or even suppressed. In symmetrical gangrene the pulsations, sometimes irregular, are ordinarily normal; they never fail entirely.

I shall have to investigate soon the points in common and the differences between the disease which we are now studying and gangrenous ergotism. I hope to be able to separate them clearly. The main diagnostic sign is given by the history of the case.

It will therefore never be superfluous to inquire minutely into the mode of alimentation of the patients.

Prognosis.

VII. From the practical point of view this is perhaps the most important part of the history of the disease. A dry gangrene is always a grave condition, and Fabrice de Hilden, during a practice of forty years, declared that he had never seen a single case of cure. Suppose a doctor called to a young woman of 25 to 30 years old, and sees her unfold the picture of which I have attempted to give an idea.

In the presence of these atrocious and persistent pains, of this deep black coloration, invading at the same time the hands up to the base of each digit, the feet up to the tarsus, the nose up to the root, I ask, what well-informed doctor who seeing, so to speak, his patient die at all extremities at the same time would not give the most gloomy prognosis?

Nevertheless the issue, as we have seen, is far from being con-

stantly fatal. This error is very natural; it is because I have committed it myself, because I have seen it committed by eminent physicians, that I wish to rectify it. Let us eliminate the first seven observations, in which there was no confirmed gangrene. One may remark, however, that these observations are not without value, if it is admitted that these cases only represent less advanced degrees of the same malady. Let us eliminate also the six cases which I have recorded under the name of doubtful observations, and which by the way ended in cure. Twelve cases remain in which there was confirmed gangrene. Of these twelve, six were fatal. But in Case VIII. the patient died phthisical long after the cessation of the attacks; it is perfectly well known that gangrene of the extremities is no guarantee against tuberculosis. In Case XIX. there was, besides contraction of the two auriculo-ventricular orifices, pneumonia with hepatisation. In Cases XVII. and XVIII. it was believed that gangrene and death could be explained by vascular lesions. I will explain subsequently the reasons which have led me to bring these cases as well as the preceding into the category with which we are now concerned. But I do not pretend to deny the value of the lesions, which, insufficient perhaps to explain everything, are not the less important as complications. Case IX. was that of a woman who became at length profoundly cachectic, and who succumbed three years after the beginning of the attacks. In her the heart and the vessels were found healthy, subsequently the condition of the extremities was relatively improved. Were the local asphyxia and superficial gangrene of the fingers the remote symptom of an alteration of the blood? or rather were the alteration of the blood and the gangrene only two different and simultaneous manifestations of one and the same diathesis? I am very far from denying it. In any case one could but say that this woman had succumbed to gangrene of the extremities.

Case X. is therefore the only one in which the patient appeared to succumb directly to the malady by progressive exhaustion. Nevertheless an autopsy was not made which prevented our affirming anything positively. And however it may be, there remain six well-marked cases, perhaps the most complete of all, in which the recovery left nothing to be desired.*

* Save in Case XIII., where there was a slight relapse.

If now we analyse the sum total of our observations from the point of view of the final result, setting aside the criticism to which I have just submitted, then we find that they are distributed thus :—

Condition stationary at the moment when the patients ceased to be under observation	6
Recovery	11
Death	8*
Total	25

The progress of the malady constitutes an element of prognostic importance. When ten to twelve days after the invasion of the severe pains one sees black dry sloughs form symmetrically on the extremities, it may be hoped that the process of mortification will soon be arrested, and that after a period of elimination, of which the duration will not exceed four to five months, the cure will be complete. If, on the contrary, the tendency to gangrene is less clearly shown, if we observe only cooling, cyanosis, bullæ returning from time to time with or without periodicity, we ought to fear that the malady may be prolonged a considerable time ; and this form, although it may not immediately compromise life, is nevertheless the most grave because it renders life miserable from intolerable suffering, and opposes a permanent obstacle to the accomplishment of social duties.

Etiology.

VIII.—In spite of the obscurity which obtains with regard to many points of this curious malady, some important etiological considerations result from comparison of the facts which I have collected. I will follow the classical division into predisposing and exciting causes.

A.—*Predisposing Causes.*

Sex.—This influence is very marked in favour of the female sex. In my 25 cases 20 are females ; 5 only are men.

Age.—The influence of age is not less important ; it obtains to such a degree that regarding it from this point of view one might be almost tempted to reserve to this variety the name

* Of these 8 fatal cases, 3 at least were due to foreign causes, viz., 1 acute phthisis, 1 chronic phthisis, 1 hydatid of the liver.

of juvenile gangrene. In the very great majority of cases the malady appeared between the ages of 18 and 30 years, the period about 25 constituting a marked predisposition. Nevertheless we have met with five children between 3 and 9 years old who suffered from it. There is a slight increased liability about the age of 40 years; finally, a single case occurred at the age of 48 years, the age of the menopause, which period places women for the time in analogous conditions to those which obtain at the establishment of the catamenia.

Temperament; constitution; previous illnesses.—All temperaments are exposed to this malady; but it affects lymphatic and nervous subjects especially. One might have believed that it would attack by preference individuals with puny constitution, or who had been exhausted by long illnesses; on the contrary, the greater part of our cases have enjoyed excellent health up to the epoch of the invasion. In one case a scorbutic cachexia developed itself concurrently with the affection of the extremities. As to previous maladies I have especially noted neuroses, particularly hysteria, and accessorily epilepsy; once tertian intermittent fever; twice syphilis; once tinea; twice there had been a recent confinement. It will be readily seen that in none of the above is there anything of special importance.

Hygienic conditions; professions.—Our cases are divided almost equally between subjects belonging to the well-to-do and the poor; but if the social condition be immaterial in the production of the malady it cannot be an indifferent question as regards prognosis; other things being equal, it is evident that one ought to expect a cure in proportion as the patients are able to receive thorough attention. A certain number of patients had *manual* occupations, such as washerwoman, chambermaid, burnisher, sculptor, &c. But as this circumstance was wanting in many other cases it appears to me that we cannot attach any importance to it.

Idiosyncrasies.—However vicious may be this word, which in reality only expresses our ignorance, there can be no doubt about the thing itself. Just as there are some individuals specially predisposed to brain, chest, or abdominal affections, so also there exists in others a true morbid liability with regard to the extremities; in these individuals the extremities cool easily, chilblains frequently occur in the winter, there is habitually a

feeling of dryness at the ends of the fingers, &c.: symptoms insignificant in themselves, but which when the malady in question becomes manifest, acquire a certain importance in relation to it.

Seasons.—Whether by chance or from some other cause, it is in autumn and spring that the disease has generally commenced, and more particularly during the month of November.

Heredity.—Here we may recall the singular observation narrated in Case XV. with respect to a little girl who, during the early months of her life, presented a remarkable tendency to local asphyxia, and at the very time when her mother was herself experiencing dry gangrene of all her extremities.

B.—*Exciting Causes.*

I have much less to say on this subject. I have sufficiently insisted already on the part which the lowering of the external temperature plays in the production of the attack; if sometimes severe cold was a necessary antecedent, more often an imperceptible change of temperature was sufficient, such as the passage from the heat of the bed to the temperature of a warm room. And as if to demonstrate the slight importance of this cause, in one case (XI.) local asphyxia and gangrene of the extremities occurred during hot weather.

The only well-marked exciting cause has appeared often in women to consist in the suppression of the menses; and as a counter-proof we have seen also a notable amelioration, or indeed complete cure, coincide with the re-establishment of this function. In Schrader's curious case it is not stated whether the monthly periodicity of the attacks had any relation with menstruation or not.

Finally, in some cases the appearance of the malady has appeared to be excited by a violent moral emotion.

Nature of the Disease.

It is of set purpose that I bring the question of the true nature of the disease into close proximity with that of its etiology. What in fact is the nature of a malady if it is not the sum total of the anatomical and physiological causes which bring it into existence? By this I mean not assuredly the internal

and proximate cause, which always escapes more or less our observation, but the appreciable mechanism by which the facts are linked together one with another, the morbid process, in one word. Let us pass in review the principal known causes of spontaneous gangrene; if we are able to demonstrate that none of these are adequate to explain the phenomena thus far recorded, that will be already a first step towards the solution of the question.

And first, *Arteritis*. Thank heaven I have not to express any opinion either upon its frequency, or upon the share which belongs to it in the different arterial changes, or to the part which it plays in gangrene in general. I take this ready made, if I may so say, from the hands of its partisans with the anatomical and semeiological characters which are attributed to it; then I place on the opposite side the cases which we have to interpret. These cases are of two kinds; some have been followed by autopsy, others have recovered.

The first are far the less numerous. In many of them from the outset the idea of any inflammatory state of the blood-vessels is excluded. I will cite amongst others that of Case IX., in which I myself made the autopsy. Two only lend themselves to a certain extent to this hypothesis, viz., that of Dr. Bernard Henry (Case XVII.), and that of Dr. Topinard (Case XVIII.). I have already quoted Dr. Henry's description and shown how defective it is. "The femoral and brachial arteries presented nothing which deviated from the normal state, but we found them adherent to the bone and closed along the line of demarcation." When dealing with a phrase which it is impossible to understand, it would be best perhaps to abstain from any judgment whatever. It seems to me, however, that these few words are enough to exclude arteritis, because the lesion, whatever its nature, was circumscribed to a very limited part of the vessels; now one of the most constant characters of arteritis is that it always occupies a considerable extent of the vessel without any well-marked line of demarcation.

M. Topinard's description would seem more conclusive: the internal surface of the arteries was of a bright vermilion tint, extended in a continuous manner—not in points or patches, not disappearing after more than forty-eight hours of maceration. But if any one thing clearly results from the discussions to

which this malady has given rise during the last thirty years, it is that redness by itself is insufficient to characterise arteritis. Laennec* considered it to be a simple result of imbibition resulting from a prolonged dying. Andral† thought that it was impossible to distinguish it from active hyperæmia. M. Bouillaud‡ himself admits, that in the majority of cases it is a cadaveric phenomenon; and this phenomenon may be produced very rapidly, since MM. Trousseau and Leblanc have observed it experimentally in horses before the heart had ceased beating. The persistence of this colour after maceration proves nothing, because a commencing putrefaction is sufficient to produce it even where it did not exist before.

To admit arteritis, therefore, it is necessary to have other characters. These characters are, according to Delpech and Dubrueil,§ alterations of the texture of the vessel, injection of the vasa vasorum; according to M. Francois,‖ velvety aspect, friability of the internal coat, &c. And in fact if arteritis can and ought to be considered as a cause of spontaneous gangrene, is it not by the obstacle which it offers to the course of the blood, either by favouring the formation of clots on the spot, as M. Cruveilhier holds, or by provoking on the inner surface the formation of fibrinous or pseudo-membranous exudations, as Hodgson holds? Nothing of the kind existed either in the cases with which I have been concerned, or in those which I have collected.

There remain then the cases not followed by autopsy. But these are still more inconsistent, if possible, with any such hypothesis. In none of them have we found either increase with widening of the area of arterial pulsations, or that redness over the course of the vessels which Broussais regarded as constant in arteritis, or those nodosities which indicate a thickening of the arterial coat, still less the important and almost pathognomonic symptom of arteritis—viz., the disappearance at a given moment of pulsations in the points where they had previously been exaggerated.

* *Traité de l'auscultation médiate*, T. ii., p. 606.

† *Précis d'anatomie pathologique*, T. ii., 1re partie, p. 350.

‡ *Dict. de médecin et de Chirurgie pratiques*, T. iii., p. 405. It is true, as M. Bouillaud admits, that on the other hand redness may be wanting in arteritis.

§ *Mémorial des hopitaux du Midi*, Mai, 1829, p. 252.

‖ *Dict. de Médicine et de Chirurgie pratiques*, Art. "Maladies des Artères," T. iii., p. 394.

In the face of these negative characters, who then, I ask, would dare to invoke the existence of a lesion which at least cannot be demonstrated in the living subject, and which even on the dead body, and when one has the specimens before one's eyes, gives rise to so many doubts?

I know that the partisans of arteritis will not admit that they are beaten, and in the last resort will invoke capillary arteritis. This is the opinion of Delpech and Dubrueil,* who have shown remarkable skill in discovering the cause of senile gangrene in this lesion. According to them, false membranes form in the interior of the last twigs of the arterial tree, which obliterate the cavity. This theory appears at first beyond all control, since it transports the malady into a region inaccessible to our senses. At the same time one cannot deny the possibility of the truth of the doctrine in certain cases where the absence of any general case of gangrene compels us to look for their origin in a local alteration of the tissues. It is with respect to these cases also that M. Cruveilhier holds an analogous opinion as regards the importance of obliteration of the small arteries of the third and fourth degree. M. Despaignet† in his thesis has given a good clinical study of these cases of gangrene produced by lesions of the capillaries, which cases are often observed in hospitals for old people. They are distinguished by the adynamia from which the patients suffer from the onset,† by the severe local inflammation which precedes mortification, by the radiating striæ around a central point along which the slough is propagated. The circumference of the malleoli is the habitual point of departure, its cause is ordinarily an irritating agent, such as a mustard plaister or a blister, applied inconsiderately. I refer to the course of the malady in order to show how it differs from the cases which I have reported. These, far from starting with an inflammatory redness, always begin with a state of atony and glacial torpor of the tissues.

Moreover, a very simple experiment, which I have already described in speaking of the symptoms, proves that there is no obstacle to the course of the blood inside the capillaries. After the skin has assumed the bronzed tint of local asphyxia which

* *Mémorial des hopitaux du Midi*, p. 241.

† *Quelques considérations sur la gangrène spontanée des extrémités.* 1859, Paris, p. 47.

precedes gangrene, if we bring to bear upon it a slight pressure there is produced a dead white patch, similar to that which is obtained by the same means on a healthy skin. But this patch, instead of disappearing instantaneously, takes one or two minutes to regain the tint of the neighbouring parts; and we can follow with the naked eye the re-establishment of the capillary circulation from the periphery to the centre of the patch. This phenomenon is quite peculiar to the case which now occupies us. Constrict the base of a finger tightly with a cord; you will produce there, it is true, a venous congestion, a bluish coloration, comparable to that of local asphyxia, but the white patch produced by pressure will disappear more quickly than in the normal state.

What do we conclude from all this? That in local asphyxia the capillary circulation is only slackened, but not arrested by an obstacle situated in the interior of the vessels, and that in a short time it becomes re-established in the canals of the smallest diameter as completely as in the healthy state. We may therefore affirm that the capillaries contain neither fibrinous plugs nor pseudo-membranes.

X. Arteritis being then placed outside the range of causation, ought we to ask for an explanation in arterial ossifications? "There is nothing more absurd," says M. Malgaegne,* "than to pretend that the ossification of arteries is a cause of gangrene." Without going so far one cannot but recall that, according to the researches of Bichat,† out of ten bodies of old men seven presented ossifications, which would lead one to consider the fact as physiological, and only to admit the influence of calcareous deposits as a predisposing cause to obliteration.‡ So much for theory. As a fact, nothing in our observations justifies the suspicion of this lesion, which is always easy to discover when it exists in the arteries of the limbs, and this is not astonishing since these calcifications are found mostly in persons advanced in age. I should not even have spoken of it, if I had not found briefly reported in an English magazine a fact, for which the name of the author commands attention. When Mr. Solly's case, previously described (Case XXII.), was presented to the Medico-Chirurgical Society of London, Dr. Bright, who was pre-

* *Anatomie Chirurgical*, T. i., cap. 9. † *Anat. gen.*, T. ii., p. 292.
‡ *Vide* Laennec, Victor Andry, *loc. cit.*

sent at the meeting, mentioned an observation of his own with regard to a very young woman who was affected with a similar form of gangrene; in addition, the end of the nose had been attacked. It was found at the autopsy that the aorta was ossified, and that a complete osseous circle was formed round its circumference. The absence of details prevents any comment on my part, but I felt bound to mention this interesting observation.

Congenital or acquired narrowing of the calibre of the arteries appears to me very worthy of attention, because I find it twice indicated with sufficient detail (Cases XVIII. and XXII.); moreover, I do not hesitate in these two cases to attribute to it a certain part in the production of the attacks. But is it right to make this the sole and determining cause of the gangrene? If such were the case we might expect that sphacelus would appear as a frequent complication in the numerous cases of arterial atresia on record. Moreover, in submitting to the Société anatomique the results of microscopic examination of his case, M. Godin expressed the view that the exciting cause—cold—which in a normal subject would have been inadequate to the production of gangrene, sufficed in his patient in consequence of individual predisposition.

The name of M. Godin, who is an authority on the subject of spontaneous gangrene, gives support to this opinion, which is one with which I entirely agree.

After having enumerated, in order to exclude them, the most common arterial changes, it would be easy for me to submit to the same criticism, the possibility of similar lesions of the veins acting as causes of the disease under consideration. Amongst these phlebitis alone deserves serious discussion. Happily the history of phlebitis is much better known than that of arteritis, the symptoms are sufficiently clear for it to be hardly possible to mistake them, and I hope that it will suffice to read attentively my observations in order to be convinced that phlebitis may be put aside as the cause of local asphyxia. Further, when we remember that the part which phlebitis plays in the production of gangrene is now regarded as more than problematical, it seems useless to prolong this discussion.

To sum up that which concerns the blood-vessels. Although structural lesions of these vessels may have sometimes played

the part of adjuvant and accessory circumstances, we have been unable to discover in such lesions a cause adequate in itself alone to the production of symmetrical gangrene of the extremities. It is scarcely necessary to add that, even if in any case we had found such a cause, it would not have invalidated the cases in much greater number in which the most minute examination has furnished only negative results.

XI. We might say as much for the organic lesion of the heart. It is well to state at once that the cases in which these lesions have been found are precisely those which have furnished us with arterial lesions, a new proof in support of the pathological solidarity too often unrecognised of the whole circulatory apparatus.

In one case (Case XVIII.) we found a contraction of the mitral orifice; in another (Case XIX.) a contraction of both auriculo-ventricular orifices. That in certain cases at a very advanced epoch of valvular affections of the heart gangrenous affections of the skin may appear is known to us all. A considerable œdema then distends beyond measure the lower limbs, which attain an enormous size. The capillary circulation becomes feeble, and an insignificant cause suffices, as for example the punctures made to favour the escape of serum, or simply the pressure of the clothes, to provoke a gangrene which is almost always preceded by erythema; but this has nothing in common with the possibility of a spontaneous gangrene, properly so-called, in cardiac affections. "In none of my own cases," says Corvisart, "and in a much larger number which I could cite of heart affections, have I ever seen the sphacelus occur which is now in question."* Laennec gives the same opinion. MM. Bertin and Bouillaud do not mention it as a complication. When such observers specially given up to this kind of research have never seen gangrene of the extremities from heart disease, are we not justified in rejecting its existence? If, moreover, we reflect on the excessive frequency of heart affections, and on the extreme rarity of spontaneous gangrene, is it not rational, when we happen by chance to note their coincidence, to seek the explanation elsewhere? M. V. François seems to me to have very happily expressed the truth when he says, "a lesion of this viscus which would be sufficient to oppose to the blood stream an

* *Essai sur les lésions organiques du cœur.* Paris, 1818.

obstacle capable of occasioning mortification of a limb, would be more than sufficient to determine general death."*

But if an auriculo-ventricular contraction is incapable by itself of provoking gangrene, we may well believe that if gangrene exists it may up to a certain point modify its form. In M. Topinard's case, for example, the patient presented initial phenomena similar to those which we have several times recorded—cooling, bluish coloration, severe pains in the four extremities, &c.; also by her sex, her age, her nervous antecedents she came into close relation with the subjects who have furnished our typical cases. Is it not probable that her affection was of the same character?

In her case, however, the permanent obstacle to the reflux of venous blood led to œdema of the lower extremities, which was opposed to complete mummification, and consequently the gangrene assumed a more or less moist character. I am happy to say that this view is also taken by M. Topinard himself, and that he inclines to believe from the progress of the symptoms that the gangrene of the feet would have been dry in his patient if the cardiac complications had not modified the condition of things.

XII. It is important to reduce to its just value the part played in our cases by the central organ of the circulation before entering on the difficult and delicate question of embolism. The last word has not been said on this subject—far from it; but it may be safely affirmed that there will be no agreement on this point unless clinical observations are considered in the light of pathological anatomy.

All the known cases of embolism of the limbs have presented up to this point a remarkable similitude in the progress of events. Either during the course of an organic affection of the heart, or even in the absence of that antecedent, suddenly profound troubles become manifest in that organ, the pulsations become indistinct, unequal, tumultuous, then a state of tranquility returns, but at the end of a few hours an acute pain is felt in a limb; the limb becomes exsanguine, cold, and insensitive; on examining it attentively we perceive that the arterial pulsations have ceased; finally gangrene appears. At the autopsy we find a fibrinous clot, an atheromatous plug situated in the arterial trunk corresponding to the diseased limb, and sometimes we are fortunate enough to discover in a remote part

* *Op. cit.*, p. 145.

of the circulatory apparatus the solid body from which a fragment has been detached and projected to a distance. This sequence of events is so characteristic, that on comparing with it the cases of which I have given the history it is clear that they will not bear a similar interpretation. Our autopsies being altogether negative from this point of view, let us return to clinical facts. Let us refer to the only one of our observations which to a superficial examination might pass for a case of embolism (XV.). A young woman three days after her confinement presented suddenly extreme cardiac irregularity with a sensation of beating in the head and fainting. Then one might have feared the formation of cardiac clots, and their escape into the pulmonary artery. But there was nothing of the kind. The only event which happened was a choleriform diarrhœa which came on a few days afterwards, and which endangered the patient's life. Then she gradually convalesced. Nearly three months passed, then cyanosis appeared, progressive cooling of the nose and the extremities, and in fifteen days there was confirmed gangrene of the limbs.

Let us examine the series of hypotheses necessary in order to regard this as a case of embolism. It would be necessary (1) that a clot should have formed in the heart under the influence of the puerperal state—this is quite possible; (2) that it should be ultimately organised; (3) that it should remain three months without giving rise to accidents, in the latent state so to speak.

This is more difficult to realise, because where would this clot be lodged? In the heart. But in that case how is it that it did not once provoke the return of those irregularities which were so alarming at the commencement? In the aorta without obliterating its calibre? But by what mechanism could it be maintained free? In the arteries of the limbs? But why then was the gangrene not immediate? But this is not all. It is necessary that on one fine day fragments of clot taking on the character of plugs should penetrate simultaneously the brachio-cephalic trunk, the left subclavian, the two iliacs, the two carotids. I acknowledge that this hypothesis of multiple migratory clots distributed regularly to all the extremities had appeared to me at first so unlikely as to be equivalent to an absurdity.

Nevertheless a recent case has shown me that to the very

letter events might happen thus. It was observed at the Necker Hospital by my colleague and friend, Dr. Bricheteau, who has communicated it to the Société médicale d'observation. This is the substance of it :—

A woman, aged 68 years, having undergone for many years all kinds of privations, was brought to the hospital for diarrhœa dating back for three weeks. Attentive examination of the different organs, and of the heart in particular, failed to discover any lesion. Under the influence of appropriate regimen the diarrhœa disappeared, and the patient improved, when all at once she fell into an adynamic condition. The pulsations of the heart became very feeble, embarrassed, and scarcely perceptible to the hand. At the same time there appeared a notable cooling of the lower extremities, then of the hands, soon accompanied by œdema. The pulse was small, thread-like, at the radials, nil in the dorsal arteries of the feet. Black patches showed themselves on the dorsal surface of both hands. The day after the œdema and chilling had still further extended, the general condition had become worse, the radial pulsations had disappeared. The pulsations of the brachials and of the femorals had become very feeble. On the contrary the pulsations of the heart had recovered more force and intensity. The patient died forty hours after the onset of these symptoms. At the autopsy a voluminous resisting elastic organised clot was found in the right ventricle. The left ventricle was perfectly free. The pulmonary artery was healthy. The aorta presented no alteration, but above its bifurcation a voluminous clot was found 8 centimetres long, soft, and blackish at the extremities, and the middle part occupied by a white centre, solid, evidently fibrinous, and of old formation. The two brachial arteries presented at their division at the bend of the elbow a small clot uniformly white and solid, folded upon itself like a worm, and not penetrating into the bifurcating branches, free otherwise, and adhering in no part to the walls of the artery, which was itself perfectly healthy.

M. Bricheteau, eliminating the different suppositions which could be suggested by the presence of these clots, thinks that they were formed primarily in the two cavities of the heart in consequence of a cachectic condition. That the contractions of the right ventricle were unable to expel the clot from its cavity,

the left ventricle on account of the greater thickness of its walls forced out the clot from its cavity, and this clot having become partially disintegrated some of the fragments penetrated into the principal arterial trunks.

After a careful examination of the specimen I was obliged to come to the same opinion.

But this fact, although of the highest importance in the general history of embolism, has no value in explaining the phenomena noted in our Case XV. In fact there remain two important differences. (1) In M. Bricheteau's case gangrene of the extremities succeeded the cardiac failure with very great rapidity, in ours there was an interval of three months. (2) In the one the complete disappearance of the arterial pulsations preceded the gangrene, in the other these pulsations were perceptible throughout.

Here again, as in regard to arteritis, one may perhaps appeal from embolism visible to the naked eye to capillary embolism. But I reply as in regard to arteritis, that in our cases the capillary circulation is only slowed, and not suppressed. Moreover embolism of the finest arterioles invoked by the Germans to explain softenings and metastatic abscesses has not been, so far as I know, invoked as a cause of gangrene. Since I must now express my opinion on the significance to be accorded to the irregularities of the heart pulsations in the case in question, I will say that by exclusion it is impossible for me to recognise anything more in them than a purely nervous phenomenon. In fact, (1) these irregularities, of which the patient was conscious, were not new to her, and consequently could not be connected with the accidental formation of a clot; (2) they appeared all at once with a dreadful intensity, then disappeared as easily as they appeared; (3) we found them present temporarily a year after the cure of her gangrene was established; (4) nothing subsequently has led us to believe that there is any organic lesion of the heart. I hold the same view with regard to the cardiac irregularities of Case XII., and still more with regard to those of Case VIII.

XIII. Finally, let us separate diabetic gangrene. Here it is true, in order that the demonstration might be complete, it would be necessary that in all cases the urine should be examined for sugar with a negative result. I have reported two cases very

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fully (XIII. and XV.) in which it is positively stated that the urine contained no trace of sugar. I believe that I can affirm the same in two others (V. and XII.). There is a strong presumption in regard to the other cases. It is completed by the absence of the characters attributed by M. Marchal (of Calvi) to diabetic gangrene. The majority of the facts recorded by this physician* refer to gangrenous phlegmons developed upon different parts of the body, and especially on the nucha. There are added, it is true, some rare cases of dry gangrene of the toes; but all are characterised by well-marked inflammatory antecedents. Although reserved on many points, M. Marchal is very explicit on this. "I limit myself to the statement that in more than forty cases diabetic gangrene and ulceration have always commenced with inflammation." This statement alone will suffice for a broad distinction between the diabetic cases and ours.

The majority of the more or less probable causes of dry gangrene are now eliminated; there remains only one which merits our further attention, viz., ergotism.

XIV. It is remarkable, after the frequent opportunities which we have had of observing this singular intoxication, and after the numerous monographs written upon it, how very little we really know on the subject. What is required is not accounts of epidemics, but individual and detailed observations. Thus in many of these narratives—and in some of the most estimable ones—numbers of gangrenous arms and legs are added up, but it is impossible to know whether in each patient one or many limbs had been attacked, and which, and in which order. All that one can say upon this point is that gangrenous ergotism is much more frequent in the lower than in the upper limbs, and that in many cases two feet have been seen gangrenous at the same time. It would be extremely interesting to learn what is the mechanism which produces gangrene in these cases. Victor Andry† advanced the view, which M. Roche‡ has since then sought to prove, that this mechanism is none other than arteritis. If this opinion were demonstrated there would be no further necessity to establish a distinction between our cases and those of gangrenous ergotism, since arteritis has been already

* *Vide l'Union médicale*, 1861. † *Journal des progrès*, &c., T. x., p. 156.
‡ *Nouveaux Eléments de pathologie médico-chirurgicale*, T. i., p. 217.

excluded. Unfortunately M. Roche proceeds only by way of reasoning, basing his argument on the similarity of the symptoms. The direct proof, the proof of fact, is absent. In a more recent work giving an account of an epidemic of ergotism observed in 1854 and 1855, M. Barrier tells us indeed that the patients presented local signs of arteritis,* but as he does not tell us what these signs were, nor by what lesions he verified them after death, and as on the fact of arteritis we are by no means satisfied, these are simple assertions of which it is impossible to take account. The same may be said of the opinion advanced by M. Boujean† (of Chambéry). This chemist having demonstrated the coagulating action exercised by the badly defined principle to which he gives the name of ergotine, concludes therefrom that the same effect is produced in the interior of the vessels of the living subject. I hardly know an author who has written from actual inspection of the state of the vessels in this malady. Ergot, says Courhaut, acts on the animal economy as a styptic. We find on post-mortem examination the arterial trunks reduced in size by the approximation of their tunics, which are of a brown colour, and that a stylet cannot be passed along their lumen.‡ In the absence of adequate information drawn from the examination of dead bodies, one would have been glad to rely upon the numerous experiments performed on animals.

Those of Read§ and Tessier‖ have often been invoked, but as M. Follin¶ has observed, these experiments cited everywhere are far from giving what it has been pretended can be drawn from them. The gangrene of the tongue or of certain muscles, the ecchymoses on the abdomen, the sanious discharge from the ears, as occasionally met with in pigs and ducks, these phenomena are far removed from mummified gangrene such as it is observed in man.

The more recent experiments of Parola and Millet are hardly

* *Gazette médicale de Lyon*, 1855, p. 181.

† *Traité théorique et pratique de l'ergot de seigle*, 1845.

‡ *Traité de l'ergot.* Châlons sur Saône, 1827. Courhaut had noted the disappearance of the arterial pulsations (*vide* the report of Mérat upon this work in the *Arch. générales de médecine*, 1e serie, T. xv., p. 459. Bourdot, cited by M. Courcelle Seneuil (*Thèse de Paris*, 1846, No. 28), found in one case the femoral reduced to the volume of the temporal.

§ *Traité de l'ergot*, p. 8.

‖ *Memoires de la Société royale de Médecin*, 1777—8, p. 587.

¶ *Traité Elémentaire de pathologie externe*, T. i., p. 114.

more conclusive, so that one cannot refuse to admit a certain value in the negative results of Parmentier, Schleger, and Model.

XV. Desiring to arrive at some opinion on this controverted point, and especially curious to ascertain the state of the arteries in gangrenous ergotism, I have made during the last six months a good number of experiments on animals. I cannot describe them here in detail, but will content myself with stating the principal results obtained, results which were very incomplete, because, as I expected, many accidents and sources of error interfered with the investigation. I experimented on dogs, rabbits, and ducks. With respect to dogs, it was found that when a small dose of ergot of rye was administered, viz., 2 to 4 grammes daily, mixed with food, there was at first an increase in the urine, and a progressive emaciation. The animal continued nevertheless to eat, but after a little time it seemed to become habituated to the poison. The experiment was continued for two months. When, on the other hand, the dose was rapidly increased up to 10 grammes in the twenty-four hours, the animal even on the second day vomited all the ingested material. Dogs seem to me, therefore, unsuitable for this kind of research. One ought to choose as much as possible animals which do not vomit.

Two of my rabbits offered most interesting phenomena. One of them had taken with impunity during a fortnight 2 grammes daily; I forced it to swallow a considerable dose, which I estimated at about 15 grammes. In the evening it was in a state of stupor and extreme prostration. On the morning after, it was found dead in its hutch. I am ignorant as to whether it had any convulsions or not. I made the post-mortem examination immediately. The right heart as well as the pulmonary artery was engorged with dark blood, extremely liquid in character; the left heart was empty.

I followed the aorta and the branches distributed to the limbs as far as possible, they were perfectly healthy; but the mucous membrane of the stomach presented forty to fifty patches of brownish black colour, rounded, varying in size from the head of a pin to a centimetre broad, and presenting a very slight elevation under the finger. Nothing in the condition of the arteries of the stomach appeared to me to explain them, only that there were in the neighbourhood small vascular arborisations

full of coagulum. These were probably the same sort of patches which Read had observed on the liver, and which he designated gangrenous patches. Lorinser and Diez, who have seen them in the stomach, hold the view (which is incorrect) that they are situated between the mucosa and the epithelium. I can affirm, after having had them examined microscopically by M. Ch. Robin, that they occupy the thickness of the mucosa itself; they are not formed by extravasated blood, but of the colouring matter of the blood infiltrated into the interstices of the glandular follicles. The mucosa of the œsophagus and of the intestines presents nothing like them. A second rabbit which had taken 25 to 30 grammes in two days died accidentally. The mucous membrane of the stomach presented the same fine dark arborisations, but almost no patches.

A single duck succumbed evidently from the effects of the poison without any other obvious phenomenon except profound depression. In this animal I found no lesion except a pronounced venous congestion associated with extreme fluidity of the blood. If therefore I should report on that which I have seen, I should be led to believe that ergot of rye given in toxic dose kills in the same way as alteratives.

But I do not positively affirm this. Since after all, experiments made on animals have only an approximate value, it is much to be desired that all opportunities should be seized of observing the condition of the arteries in ergotic gangrene in man.

XVI. Reduced to clinical facts alone, let us see if our cases agree with the hypothesis of an intoxication of this kind.

At the outset there is a notable difference as to the subjects affected. Noël, surgeon at the Hôtel Dieu of Orleans, who described the epidemic of 1710, made the remark that this form of gangrene attacks men by preference. What is most astonishing, says he, is that this malady does not attack women, at most a few little girls.*

The same observation has been made in subsequent epidemics. I have previously established, on the contrary, the great predilection of symmetrical gangrene of the extremities for the female sex. But let us go further.

Amongst the facts reported previously there is a certain number in which the cause is not indicated; but in many the

* *Histoire de l'Académie des Sciences*, 1710.

social condition of the patients and their abode seem to negative the possibility of ergotism. Four times inquiries have been made in this direction, information has been obtained, but it has been unsatisfactory. Finally, there are three cases which by a kind of fatality seem expressly devised so as to leave the mind in some doubt on the subject (IX., XII., and XV.).

In Case IX. we know that at the period when the first symptoms appeared, the patient, who then lived at Limoges, had been brought up for sixteen months on bread made exclusively from rye flour. Many questions were asked with a view to discover whether the rye flour had been altered; the fact that it was by taste and not by necessity that the patient had adopted this kind of bread would, so far as it goes, be against the hypothesis that the rye flour was ergotised; to anybody who knows the disgusting appearance and execrable taste of ergotised bread such a preference would be inconceivable.

But it is more important to note that in reality the symptoms presented by this patient were not by any means those of ergotism. In her the malady did not go beyond local asphyxia, and the formation of bullæ and of very small eschars on the skin of the fingers. Moreover it was continued for three years after the suspected alimentation had been suspended, with alternations of improvement and relapse. Now I do not know that there exists a single example of ergotism in which this progress has been observed; mortification has taken place all at once, sometimes to a considerable depth, elimination may be a longer or shorter time in its accomplishment, but there is no such thing as chronic ergotism, properly so called.

The child who was the subject of the 12th case had been brought up in the Cevennes mountains; there its nourishment consisted of chestnuts and of bread made with buckwheat and rye. But in the first place we are ignorant absolutely as to whether the rye was ergotised or not; and, secondly, we know that during eight months the child only ate white bread.

Finally, in Case XV., the patient, who was confined on November 28, 1860, had taken during her labour 1½ gramme of ergot of rye. The first symptoms appeared on the following 18th February. So improbable is the supposition, that I hardly dare discuss the question whether so small a dose of ergot would have been sufficient after an interval of three months to induce

gangrene, when thousands of women take every day a larger quantity with impunity. Nevertheless for those who are difficult to convince, it is necessary to remove this difficulty.

There exist, it is true, a few rare examples of gangrene developed after the administration of ergot in obstetrical doses. Such is M. Robert's* case, in which 12 grains (0·6 centigrammes) had been prescribed and swallowed; whereupon this physician treats as fools the practitioners who should dare again to employ this medicament. But in this case, according to his statement, the gangrene appeared some little time after delivery. The patient succumbed one month after accouchement; the progress of events was therefore rapid. Are our Cases XII. and XV. then the only ones in which the tonic action of ergot of rye was manifested at several months' interval? After careful search I have found a third, in which this remote action of ergot was assumed. This case is sufficiently curious to be recorded.†

February 1, 1854.—Catharine C., aged 22 years, domestic servant, presented herself at M. Maisonneuve's consultation, complaining that she had not been able to use her fingers for more than a month. The two hands presented an aspect sufficiently striking and characteristic to attract attention, and make one think of some serious disease. The age of the patient, the absence of all traumatic cause, and the characteristic aspect of the affection, left no doubt as to the existence of a gangrenous ergotism. The patient moreover confirmed immediately the diagnosis by announcing that she had always lived on rye bread, that this was regarded as damaged when four months ago she had left the mountains of Auvergne in order to come and live in Paris. Up to then nothing in her health had made her aware of the hurtful influence to which she was subjected. Two months after her arrival in Paris she became very sensible to cold, and her hands and her feet became swollen and covered with numerous bullæ. The patient believed that she was suffering from chilblains, and although she had never been subject to them previously she was not disquieted by them. But this irritation, instead of subsiding, became aggravated from day to day, and ended by rendering all work impossible, and forcing her to enter the hospital.

The two hands presented changes not to the same degree but

* *Gazette médicale*, 1832, p. 819. † *Gazette des hôpitaux*, 1854, p. 69.

evidently of the same nature. The first thing to arrest attention was the uniform dark colour of the last phalanx of the little finger of the right hand, and that of the middle finger of the left hand. This dark colour disappeared almost abruptly at the level of the posterior border of the nail. The extremities of the other digits presented a violet tint, which was not uniform, but was probably of like nature with that above mentioned. These extremities were also very cold. The fingers, besides being stiff, cold, and painful to pressure, were thin, pointed, and shrivelled, and were quite useless. The two hands were covered here and there with reddish erysipelatous-like patches, and were the seat in some spots of desquamation and of cracks, the probable sequels of the chilblains complained of by the patient. The radial pulse was perceptible at the finger, and was even moderately full in character. The feet, although tumefied in some places, showed no sign of approaching gangrene. The limbs had never been the seat of any spontaneous pain, and there had been no vertigo at the beginning of the affection.

If it were possible to rely upon the statement of the patient, this then would be another case in which gangrene had set in more than a month after the cessation of the tonic nourishment. Now this woman had always eaten rye bread. In truth we could not describe this as a case of gangrene from ergotism, and one might have been tempted to call it rather gangrene from the use of white bread!

This long interval appears strange when we remember that on comparison of the different epidemics M. Follin has found that the first symptoms of ergotism generally appear after five or six days of the use of this kind of alimentation.

This objection seemed to me so strong that I thought it desirable to obtain information from original sources. I wrote therefore to Entraignes (Aveylon), the place of sojourn of this young woman before her arrival at Paris. This is what M. Calsat (who was doctor and mayor of that locality) replied:—

"The young woman, Catharine C., no longer lives at Paris; she returned to Entraignes about four years ago, after having been married in Paris. She was in good condition when she returned. I can affirm that during the forty-nine years that I have practised in this district, I have only seen rye attacked by ergot once, and in such small quantity that I have hardly been

able to collect it for my medical use. As to gangrenes, whether of toes or digits, I have not met with a single case, nor learnt that any of my colleagues of this part of the country have had a case to treat."

This testimony, assuredly more reliable than that of a poor servant, is such as to make one believe there must have been some misunderstanding of the case. The form and progress of the symptoms, their localisation to the upper limbs, and the age and sex of the subject, would have led me to the view that this case belonged to the same group as that which I have already described. I cannot unfortunately with regard to ergotism draw upon any experience of my own. Nevertheless some facts with which I am acquainted lead me to think that the use of bread made with rye of bad quality does not suffice by itself to produce gangrene.

It is necessary in addition to have the unknown quantity, which for want of a better word we are forced to call predisposition. Now this predisposition may become settled in certain families. The following is one of the most curious examples still unedited:—

On March 1, 1855, there were admitted to the Children's Hospital, under the care of M. Guersant, two brothers, named Vidal and Jean R., aged—one 14 years, the other 12. They had lost both parents at the same time during the cholera in 1849. Dependent upon public charity they had been taken to different abodes, and for the last four years they had been living in an agricultural settlement situated two leagues from Gien (Loire). On their admission Jean had two feet mummified up to the tarsus; a deep groove separated the dead from the living; at the bottom of the wound the articulations were seen quite exposed. In Vidal the five toes of the left foot were gangrenous; on the right side there was only a superficial mortification of the last phalanges of the first and of the fifth toes. In neither was there any symptom of arteritis or of phlebitis. In Jean's case a few cuts with the scissors sufficed to detach the dead parts. Enormous wounds resulted, which suppurated for a long time. In the absence of flaps cicatrisation appeared impossible. After having temporised for awhile, M. Guersant saw that it was necessary to amputate the right leg at the seat of election. Then it was found necessary to perform sub-malleolar amputation on the left side.

In Vidal's case the progress of events was much simple The sloughs having separated, cicatrisation soon took place.

I have taken these details from M. Guersant's note book.

I have recently sought out Jean R., now aged 19 years He is a very intelligent young man, and has given me circumstantial information on the commencement of the illness. His brother and he had undergone great hardship; the winter had been very severe. They worked in sabots in the quarries. On their return to the house they walked with bare feet on the floor Both had had chilblains all winter. Jean began in the early part of January, 1854, to feel severe pains in the lower limbs; in Vidal symptoms began at the moment when the gangrene was already confirmed in his brother. With regard to the cause of this illness Jean R., whom I interrogated with all possible care, affirmed to me that their food was composed in great part of rye bread, that at that time the rye was ergotised, and the description he gave me appeared to be conclusive. He added that at the beginning of the illness there was a period of delirium. But what appears to me essential in this history is the following: thirty-six children lived at this settlement. All were subjected to the same regimen, ate the same food, and were exposed to the same hygienic surroundings. Now of these thirty-six, two only were affected, and these were the two brothers. However one may explain this singular coincidence, it seems to me worthy of the most serious attention.

I may perhaps be pardoned for having entered upon this long discussion with regard to gangrenous ergotism. The description which I have given of symmetrical gangrene of the extremities would have had no value, if there had remained any doubt as to its being distinct from the lesions produced by ergot.

XVII. I have said what this gangrene is not. It remains now to ask what it is. Upon this question it is necessary to be more circumspect. It has long been admitted that gangrene might be produced by alterations of the blood. But to admit this alteration, without knowing wherein it consists, is in truth to have made a very slight advance. Nevertheless it is possible, and since the symptoms described as ergotism have probably no other cause than ergot, there is nothing fundamentally absurd in supposing that there exists around us some mysterious poison, the accidental introduction of which into the economy may be

able to determine the symptoms which are now under consideration.

Gangrene has been said to be produced by opium, and also by damaged potatoes. M. Jobert has cited cases of dry gangrene produced by septic matters, &c. If it be so, it is much to be desired that new researches should reveal to us the nature of this mysterious agent. In which case there would still remain that which remains to be done for ergot—viz., to investigate the mechanism of the poisoning. Meanwhile it appears to me possible to invoke another cause. Can a vice of innervation produce gangrene? M. V. François admits this variety as probable. But it is all-important here to establish a distinction between nerves of relation and the system of the great sympathetic.

With regard to the first, our knowledge is very limited. Although the section of these nerves leads infallibly to paralysis, it is infinitely rare for it to cause sphacelus. Nevertheless M. Longet has observed that many months after section of the sciatic nerve in dogs, the paw becomes covered with gangrenous patches, loses its hair and its claws, and that the limb begins to show signs of fatty degeneration.*

Haller had seen similar facts. M. Bernard has observed, after the section of the fifth and of the seventh, a constant lowering of temperature of 1 to 2 degrees in the paralysed part. M. Romberg† has specially studied the effects of cutaneous anæsthesia on nutrition. He reports them under three groups. 1. Diminution of calorification. He cites the history of two patients who, after traumatic lesions of nerves of the lower limbs, presented a notable diminution in the temperature of the paralysed limbs. 2. Inaptitude of the affected part to resist changes of temperature. These same patients could not undergo the contact of cold water, or be exposed even to a moderate heat, without the occurrence of blisters on the ends of the fingers. We may associate with this, Dieffenbach's remark, that after plastic operations of the nose blisters are apt to arise on the least chilling, and that this phenoménon ceases on the re-establishment of sensibility. 3. Slowing of the capillary circulation, whence a livid colour appears. Romberg cites many cases,

* *Traité de physiologie*, T. ii., p. 93.

† *Lehrbuch der Nerven Krankheiten*, 1 Bd., p. 232. Berlin, 1851.

gathered from different authors, of sections of nerves, which led either to ulcerations or to the appearance of small vesicles occurring from time to time on the paralysed digits, or to an epidermic desquamation, and loss of nails and hairs. I myself observed a fact of this kind during the time that I was resident under M. Robert in 1858.

A man had a cicatrix at his elbow, which, from its situation, led us to believe that the wound had affected the ulnar nerve. All along the course of this nerve, quite definitely, there appeared from time to time vesicles which were filled with reddish serosity, these dried up, and fresh vesicles appeared soon afterwards at a short distance.

It appears then to be proved that lesions of nerves may lead in certain circumstances to alterations of nutrition, which are somewhat profound. But let it be noted that in all these cases there is a traumatic antecedent, which is wanting in our observations; that generally, if not always, there is the coincidence of a true paralysis; finally, and above all, that it is not true gangrene which is produced, and that the anatomical form of the lesion differs essentially from that which we have described. So that in the actual state of knowledge we are authorised in believing with M. Follin* that the cessation of nervous influx, whilst blunting the sensibility of the parts, favours the action of causes which without it would remain without effect. Moreover, when we reflect on the numerous anastomoses which the nerves of the cerebro-spinal system have with the great sympathetic more or less near their origin, we cannot affirm that the lesion of nutrition, when it occurs, is not dependent on a lesion of the ganglionary system. This appears to result from M. Claude Bernard's experiments, and this leads us naturally to consider the bearing of his experiments on our subject.

XVIII. The physiology of the circulation has been enriched in late years by one of the most beautiful discoveries of the century, with which is coupled the name of the illustrious professor whom I have just quoted. In repeating the experiments of Pourfour du Petit on the section of the great sympathetic of the neck, M. Bernard recognised that this lesion is accompanied always by a very notable elevation of temperature in the corresponding parts of the head. The same fact, studied subsequently by M.

* *Loc. cit.*

Brown-Séquard, and by M. Schiff, of Berne, has been not only verified but generalised. Since then the doctrine of vaso-motor nerves has passed from the domain of hypothesis to that of fact. On the one hand anatomy demonstrated the existence of smooth muscular fibres in the middle coat of the arteries, on the other physiology established the subordination of these fibres to nervous influence. Thus Valentin's phrase was realised, "The vascular contractility is the moderator of the course of the blood."

It was reserved to M. Bernard to add another discovery to the preceding. He demonstrated that the branches of the lingual nerve which go to the submaxillary gland have a property which is precisely inverse to that of the great sympathetic: when cut they provoke an acceleration of the blood current in that vascular region; galvanised at their peripheral end they cause slowing of the circulation; these vessels are thus subjected to two opposite local influences, of which the equilibrium is necessary for the maintenance of the normal circulation. Whence arises this conclusion: the pressure of the arterial system and the cardiac impulse are common mechanical conditions which the general circulation dispenses to all the organs. But the special nervous arrangement which has to do with each capillary system and each organic tissue regulates in each part the course of the blood in relation with the chemical functional conditions of the organs; these nervous modifications of the capillary circulation take place on the spot, and without any disturbance of the circulation of the neighbouring organs, or still less of the general circulation. Each part is united to the whole by the common conditions of the general circulation, and at the same time by means of the nervous system each part can have a circulation of its own and become physiologically individualised. Now whether this takes place only in the fine arterioles, the capillaries properly so called remaining foreign to it, in consequence of the constitution of their walls; or whether, on the contrary, according to Hastings and Milne Edwards, the capillary vessels themselves may take part, is of little importance from the physiological ar[illegible]point of view; that which is certain is that [illegible]he arterial and venous systems import[illegible] having to do with the volume, the te[illegible]

the parts, and of which the vascular contractility can and ought to render an account.

But here a serious difficulty presents itself. By virtue of what mechanism does this elevation of temperature take place, which M. Bernard has proved for the first time on the rabbit's ear? There are two theories on the subject: the first is a far-off echo of the old doctrine of Galen, who saw in the pulse a phenomenon of active expansion of the arteries; this theory maintains that the dilatation of the capillaries, whence results the increased warmth of the part, is an active phenomenon. Consequently inflammation would be, as Broussais held, an exaltation of the vital properties of the region, an excess of force. According to the second theory the dilatation of the capillaries is purely a passive effect, a true paralysis, and the increase of temperature results from the free passage at a given moment of a larger quantity of blood than normal, with more than normal capacity of transmitting to the extremities the heat of the centres, and of resisting the causes of chilling. The doctrine of activity was strongly maintained by Graves long before the discovery of the vaso-motor nerves. He considered that in all congestive phenomena the initiative was taken by the capillaries. He was opposed strongly to the theory of the vis a tergo; he developes the opinions of Carpenter upon what that physiologist calls the capillary power, which is charged, according to his view, with regulating the flow of nutritive liquid and controlling the growth and maintenance of the parts of the body. We recognise here the famous theory of the "demand of the blood" held by John Hunter and Tommasini, and at a later period modified somewhat as to form, but the same fundamentally, as the system of attraction of Wharton Jones and Paget, who believe in a true affinity between the blood and the parenchymatous tissues.

I should not have dwelt upon this subject, if at the same time that he discovered the primordial fact M. Bernard had not given to this doctrine the support of his authority. According to his view, from the fact that the temperature is raised after the section of the great sympathetic, we must not conclude that there is a paralysis of the capillary vessels. "This circulatory phenomenon," he says, "appears to me to be active, not passive."*

* *Cours de* 1858, p. 510.

In other words, the ganglionary nervous system exercises a direct influence on calorification; its section does not act positively upon the circulatory state, but upon the heat production by an inscrutable mechanism like that of the vital properties.

XIX. Ought we to admit this interpretation? In a still recent thesis—one of the most remarkable which have been sustained at the Faculty of Paris*—my colleague and friend M. Marey has combatted with talent, and in my opinion has successfully refuted, the arguments of the eminent professor of the Collège de France. Not having either authority or space sufficient to enter here upon this difficult discussion, I can only refer the reader to that excellent work. Amongst the points which M. Marey seems to me to have decisively established, I will limit myself to the following, which bear directly on my subject:—The true obstacle to the course of the blood, and consequently the cause of the tension of the arteries, consists in the friction of the liquid against the walls of the capillaries. There is a constant antagonism between the tension of the blood and the contractile force of the vessels which support it, so that, contrary to the general opinion, their dilatation produces a more easy passage of the blood, and an excess of calorification; their contraction produces inverse effects.

The muscular fibres of the arteries supplied by the great sympathetic are entirely comparable with those of the organs of vegetative life, and as such susceptible in the physiological state of contraction, fatigue, and of adaptation to work, in the pathological state, of spasm, and of paralysis.

It is physically impossible that a tube with membranous wall should actively dilate under the enormous resistance opposed by atmospheric pressure.

This law, enunciated by Hunter, remains indisputable, viz., that in the warmest peripheral parts the temperature never goes beyond that of the centres. Consequently, according to M. Marey, the phenomena of calorification and of redness observed by M. Bernard upon the rabbit's ear ought to be considered as purely passive.

I shall not follow my distinguished colleague in his ingenious

* "Recherches sur la circulation du Sang a l'état physiologique et dans les maladies." *Thèse de Paris*, 1859.

views upon vascular debility considered as a cause of inflammation; in my sense there is in inflammation quite another thing than a simple phenomenon of irrigation, otherwise how could one conceive it in the tissues which have no vessels, such as the cornea? I hold that the famous aphorism, "Ubi stimulus ibi fluxus," will still remain, clinically at least, indisputable. I will add only that in the capillary circulation there are two elements which we must carefully distinguish; the rapidity of the current, and the quantity of the blood which is found at a given moment in a given region. Of these two elements the first is only a question of mechanics, and affects us to a moderate degree.* The second has an immediate interest, since the possibility of nutrition and of its proper performance of function are related to the quantity of blood in contact with the living solid. Now from what we have just seen, the quantity of blood in circulation in a part increases in the state of relaxation of the capillaries, it diminishes when they are narrowed or contracted, it becomes nil if the narrowing goes on to the suppression of the lumen of the vessel.

XX. Starting from these facts, let us see if there is any temerity in admitting that in certain circumstances there may occur a spasmodic contraction of capillary vessels. Far from this being so, this spasm is precisely one of the most common phenomena of pathology. We have only to look for it to find it. What is the common phenomenon of frost bite? and what does that deadly pallor, that chilling of the extremities which occur in the algid period of cholera, and the intermittent fevers signify? What means the bluish tint which affects the nails, the violet aspect of the extremities so habitual in general paralysis, &c.?

What is the significance, in one word, of algidity, that symptom which is one of the most frequent that we have to observe, if it is not a fact of transient ischæmia, a condition only to be explained by a spasm of capillary vessels?

Let us take now algidity in itself, and let us see how it terminates. In one of two ways it may give place to what we

* M. Marey has also the merit of having pointed out the difference between what is called the *quantitative rapidity* and the *molecular rapidity*. "From the rapidity of each molecule being augmented at a contracted part, it does not follow that the contraction is a cause of the absolute rapidity of the current—quite the contrary; this confusion is based on a misunderstanding."

have agreed to call the period of reaction, characterised by heat and redness which go beyond the normal state.

This mode of termination, by far the most frequent, is in some sort physiological. It takes place by virtue of that general law according to which every muscular contraction is followed by relaxation; if contraction has been spasmodic, excessive relaxation will extend up to momentary abolition of the tonicity of the muscular fibres, and this tonicity will only be re-established by degrees.

Or, on the contrary, the cause continuing to act, the capillary spasm may extend beyond its habitual duration; the parts deprived of blood lose the elements of nutrition, and gangrene occurs. This is what happens in algidity caused by the impression of cold. It is generally held that in this case there is freezing of the liquids in the interior of the capillaries, then rupture of these vessels at the time of the passage of the icicles to the liquid state. I do not deny that this may occur in certain cases, but nobody so far as I know has ever seen these ruptures, and they seem to me to be difficult to admit when one considers the extreme elasticity of the membranous walls of the vessels. Is it not more simple to admit that gangrene may occur primarily, being caused by the persistence of the capillary spasm which has occasioned at the commencement the exsanguine condition of the extremities?

Is it not possible that these different phenomena, which take place every moment under our eyes, and under the influence of well known causes, may occur spontaneously, and explain to us in a very satisfactory manner the different degrees which we have noted in symmetrical gangrene of the extremities?

It commences by a spasm of the capillary vessels, and let us remark that this spasm occurs in subjects who are characterised by a nervous predominance, young women, hysterical people, children, &c. In the simplest cases those in which the malady remains, if I may so say, in a rough state, the exaggerated peristaltic contraction of the capillaries drives the blood before it, the extremities become pale, withered looking, and insensible. This is the "dead finger." But this phenomenon does not persist long enough for gangrene to follow. To contraction succeeds relaxation, the circulation is re-established, and every-

thing returns to the normal state after a period of reaction more or less painful. Such is *local syncope*, in which the venules participate in the contraction of the arterioles.

Local asphyxia is only a more advanced condition. After an initial period of capillary spasm there occurs a period of reaction, but it is incomplete reaction. The vessels which return first to their primary calibre, or even beyond, are naturally those which present in their structure the fewest contractile elements, viz., the venules. At the moment when these are opened, the arterioles being still closed, the venous blood, which had been at first driven back into the great trunks of the dark blood system, flows again into the finest vascular divisions, and then the extremities will take on that tint varying from blue to black which is a certain index of the presence of venous blood in the capillary network. This explains two phenomena to which I have called attention in speaking of the symptoms. The first is that the cyanotic tint of the extremities succeeds in general to an extreme pallor, or in other terms that syncope precedes asphyxia.

The second is that at the outset at least the asphyxiated parts have not that very deep tint which one observes following on a violent constriction of a limb; in this last case, in fact, there is venous blood extending into arteries of a calibre which is relatively considerable. In local asphyxia the venous reflux does not go beyond the capillary network properly so-called; it results therefrom that the colour which is observed has a certain transparence; it is a mixture of cyanosis and pallor. During the convulsions or painful crises, effort determines a more abundant reflux still of venous blood, and the extremities become warm at the same time that they become black (Case VII.).

In the meantime the vis a tergo having ceased its action on the venous side, the return circulation is no longer favoured except by the causes which in the physiological state are limited to the part of accessory conditions; such are the muscular contraction of the limbs, the play of the valves, the aspiration exercised by the thoracic cavity, &c. Consequently the blood stagnates even in the great venous trunks, and then are produced along with a very slight œdematous suffusion those cutaneous livid venous markings which have been rightly

compared to those which the prolonged use of warming pans produces.*

This state may be chronic, and the spasm of vessels may only have a limited duration so as to return in irregular or intermittent attacks. This case is itself susceptible of many degrees: at one time everything is comprised in local asphyxia pure and simple; at another, each attack having a longer duration, the tendency to gangrene is more pronounced; bullæ form with very small sloughs, then at the moment when gangrene is on the point of becoming confirmed the parts revive momentarily, to be soon afterwards attacked in the same way; and this may go on for years. Finally it may happen, although much more rarely (but we have collected several examples of it), that the capillary spasm comes on all at once with an intensity and a duration altogether extraordinary. Syncope and local asphyxia succeed one another rapidly; the venous blood becomes insufficient to nourish the parts; the colour becomes deeper and deeper; small blood-stained infiltrations take place through the walls of the venules; these walls may themselves become granular; in one word, there is confirmed gangrene, and gangrene which may go on to the fall of many ends of fingers or toes.

But on final analysis all these varieties of functional lesions, which may each present an infinity of shades, realise always one or other of the two conditions which I have previously indicated as essential to dry gangrene; that is to say, absence of blood, or presence of blood unsuitable to nutrition. When the principal artery of a limb is found obliterated by a clot, or when its last ramifications are contracted on themselves up to the obliteration of the lumen of the capillary vessels, fundamentally the result is the same, and these conditions, although very different, all end in the impossibility of those molecular changes taking place which constitute the intimate phenomena of nutrition.

And now why is it the extremities only which become gangrenous? It is because it is necessary, in order that things should arrive at this point, that there should be a combination at one and the same point of two important causes of chilling: first, the loss of afflux of a warm liquid; second, a powerful radiation capable of causing the acquired caloric to be lost; all things

* Are the spontaneous pains of syncope and of local asphyxia in relation to the vascular contraction a sort of painful cramps of arteries?

being equal, it is evident that the parts which radiate most will become gangrenous first. Thus it is at the extremities that this second condition exists at a maximum; the digits, the toes, the ears, the nose, are certainly the parts of the body which present the most considerable surface relatively to their volume.

It is probable that at times the primary phenomenon, the capillary spasm, is not limited to the extremities, and is generalised over a more or less extensive area of the body, as indeed is indicated by the excessive pallor of the skin which has been noted in some cases.

But in these cases this cause of itself alone has not sufficed to bring about a general gangrene, because the trunk, the face, the roots of the limbs are situated near enough to the centres to preserve a sufficient heat for the maintenance of life.

It is not impossible that the variety of gangrene which approaches nearest to ours, viz., ergotism, may depend on an analogous mechanism. Everybody knows the obvious action which ergot of rye exerts on the contractile fibres of the uterus; there would be nothing astonishing in that it should produce the same effects on the smooth muscular fibres which enter into the composition of the arteries, and which are in fact, or as nearly as possible, the same histological element; in this case the tonic action would show itself by preference in individuals whose muscular fibre is endowed with an excessive irritability, and this would be the reason of those individual predispositions of which I have previously spoken. Perhaps, again, we ought here to take account of another influence. M. Poiseuille has very well demonstrated that the chemical nature of bodies held in solution in a liquid has a sensible influence upon the rapidity of flow in canals of narrow calibre, and this independently of viscosity. Does ergot communicate to the blood a property of this kind?

Finally, let us not forget that all this exists in the organism, and that if we can hypothetically study separately the capillary vessels, and the parenchymas in which they are plunged, in reality all these elements are united with one another in the most intimate fashion. I admit therefore very willingly that, by virtue of a cause which escapes us, the anatomical structure of the extremities may predispose them to gangrene, just as the lung is predisposed to inflammation, as the muscles are to

hypertrophy, &c. The striking symmetry which often occurs would favour such a view. We might conceive that up to a certain point, a general cause being given capable of acting upon the capillary circulation, this cause might affect simultaneously paired extremities. We might conceive less easily how without a very special predisposition it might manifest its influence upon points perfectly similar, and with the same intensity on each side of the body. These are questions which present themselves naturally to the mind; they are not the only ones. But in the actual state of our knowledge there would be some temerity in attempting to answer them.

Treatment.

XXI. It will, I trust, be readily understood that for a malady of which so many points are still obscure, I am not quite prepared to formulate a complete treatment. It is desirable, nevertheless, to state the principal indications which are to be fulfilled, and especially some gross errors which are to be avoided.

We have seen that in one case (XV.), dominated by the desire of irritating and stimulating the torpid parts, I advised the patient at the beginning of the affection to use local mustard baths. I have reported the disastrous results which immediately followed the employment of these means. This is what I think takes place in such a case: the application to the extremities of a powerful modifying agency, whilst locally combating the vascular spasm, causes the vascular spasm in some sort to retrograde to the larger arteries; hence the sudden eruption of venous blood into parts which it did not previously occupy, and consequently blackness of the extremities rising much higher towards the root of the limbs. Whether this be the explanation or not, we must avoid the use of a therapeutic measure which is as treacherous as it is dangerous, and in general terms we must forbid the employment of energetic rubefacients.

Aromatic substances have been employed with some advantage; thus embrocations of benzoin appeared in one case to lead to improvement. When the spontaneous pains felt by the patients do not prevent our being able to touch their limbs, it is well to rub them gently with a piece of flannel dipped in eau de Cologne, or in peppermint water slightly sharpened with ammoniacum.

I have seen this treatment diminish in a very evident manner, and somewhat rapidly, the dark colour of the fingers, or at least circumscribe it to the extremities of the ungual phalanges. It is true that it reappeared some time afterwards; but an improvement even transient is not to be disdained in an affection which is so painful. Perhaps the simple fact of a soft and prolonged friction was responsible for this half success. We have seen in one case (VII.) a very good result obtained by the local application of induced electricity. This measure, at first very painful, led to a complete cure after ten or twelve applications in a week. The case is too briefly reported for an absolute conclusion to be drawn from it. Nevertheless electricity being one of the most powerful of the known modifying agencies of contractility, it would not be surprising if favourable results could be obtained from it. It is a method to be tried with all requisite prudence.

Amongst the topical remedies of which the employment is recommended in some of the cases are aromatic spirit; the ointment used by M. Sandras, of lard 60 parts and sulphate of strychnia 1 part; and especially compresses soaked in chloroform, which in one case led to marked improvement in several attacks. As to cold irrigations, the benefit attendant upon their use seemed to be balanced by the inconvenience, that on their suspension painful recrudescences of the malady occurred. If used in any given case the greatest caution should be observed in withdrawing the application.

Are local bleedings advantageous? Surgeons know very well that after a plastic operation, when the newly restored part is menaced with gangrene, the application of leeches over the patch is often an heroic remedy. By analogy one may be led to employ it upon the extremities in a state of grave local asphyxia. Case VII. offers us a favourable example of the use of this therapeutic measure.

It is hardly necessary to add, that to all these methods of treatment it will always be opportune to add the envelopment of the affected limb in close fitting material, and especially in cotton wool. If radiation has upon the progress of the symptoms the dangerous influence which I have attributed to it, it is evident that it must be useful to try to neutralise this cause of chilling.

Gangrene once confirmed, there is no need for any further

local treatment except waiting until the sloughs become limited. The question of the proper time for amputation in cases of gangrene is far from being settled in surgery. But in the variety which now concerns us (whilst eliminating, as is well understood, the doubtful cases in which the entire limbs have become gangrenous), this question can hardly arise. With a mortification so limited, with the certainty that the elimination will take place satisfactorily, it is evident that surgical intervention can only lead to inconvenience, the more so that in some cases the great extent of the sloughs of the skin might lead us to believe that there was a gangrene of a whole toe, whilst in reality the lesion is very superficial. We are therefore limited, after the subsidence of acute symptoms, if the sloughs should be a permanent difficulty, to the partial cutting them off, and to favouring their removal by gentle traction.

XXII. Finally, all these local means are only secondary, since manifestly we have to do with a malady of general origin. If I am not deceived as to the mechanism which produces it, the desideratum is to find a medicament which would have a constant resolving action on the smooth muscular fibres of the arterial coats.

Is opium such a medicament? We know the unbounded confidence which Pott accorded to it as curative of gangrene. Since his time we have been compelled to abate some of the enthusiasm roused by the early cases in which this drug was employed. Nevertheless in every causal condition, and quite apart from all theory, we must acknowledge that opium, being the first of the narcotics, at least responds to this primary indication—viz., to calm the atrocious pains of mortification of the extremities. In this respect it will always find its use, which, moreover, is free from any inconvenience.

In one of my cases, in which the cure left nothing to be desired, Vichy water had been given in strong doses. Was it by fluidifying the blood that it contributed to the satisfactory result? Did it really contribute to the result? I do not know. In any case this fluidification of the blood from the theoretical point of view must be advantageous.

Quinine enjoyed for a long time during the last century an immense reputation as a specific for gangrene. Although its reputation as a specific may be gone, yet in cases where there is

a well-marked intermission, sulphate of quinine as an antiperiodic ought to take the principal part in the treatment. It will not always cure—one ought to be forewarned of that—but a skilful therapeutist will be able at all events to take advantage of the modification which this remedy will infallibly introduce in manifestations of the disease.

All the measures which I have enumerated ought to be seconded by good alimentation. As in the severest attacks the patients preserve a good appetite, whilst they have no fever, it would be irrational and cruel to deprive them of nourishment. In spite of the successful results attributed in one case to general bleedings (Case XI.) I should not hesitate to forbid the use of lowering measures. Often the patients are young, nervous, chlorotic women; in such cases especially a tonic and substantial *régime* is imperative; it is perhaps the one indication which is more important than all the rest.

In the matter of general treatment each practitioner must be guided by circumstances. For my own part I should, I confess, sincerely regret if I have given an erroneous interpretation of the facts which have come under my observation. But I should not pardon myself if in consequence of theoretical views I should lead physicians into the beaten tracks of a hazardous and fatal therapeutics. It is in this part of our art more than in any other that we must be specially careful of the *a priori* method. Happy shall I be if at least in attempting to make the nature of the disease precise, I shall have been able to indicate in what direction it may be well to seek the remedy.

Moreover, in conclusion, I repeat that this malady, so strange, so formidable in appearance, is far from having in reality all the gravity which at first one would be tempted to attribute to it. To moderate the pains, to prevent the use of unsuitable measures and doubtful remedies, such ought to be in the majority of cases the part played by the physician. Nature will do the rest. We shall be sufficiently satisfied, although we cannot immediately relieve our patients, if we can still encourage them with the hope of a probable and approaching recovery, and should this point be the only one which clearly results from the work just completed, I should not regret the pains which I have bestowed upon it.

NEW RESEARCHES

ON THE

NATURE AND TREATMENT OF LOCAL ASPHYXIA OF THE EXTREMITIES.

By Dr. MAURICE RAYNAUD.

TRANSLATED BY

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NEW RESEARCHES ON THE NATURE AND TREATMENT OF LOCAL ASPHYXIA OF THE EXTREMITIES.*

THE account which I gave a few years ago of local asphyxia and symmetrical gangrene of the extremities appears to have been accepted by the medical public. New observations have been published in France and abroad, theses have been sustained, and the affection in question has found a place in treatises on pathology. In fact, as we always find with regard to diseases hitherto undescribed, it has proved to be much less rare than had previously been imagined. When once attention has been called to the subject, cases which would have escaped recognition are recorded, and the number of known facts rapidly increases.

Perhaps I may now be allowed to criticise the name which I gave to this disease. I have found many defects in it. First, there is always a real inconvenience in giving two distinct names to one and the same object. Local asphyxia and symmetrical gangrene are not two distinct maladies, but two degrees of one and the same malady. Of these two degrees, the second is often absent, which prevents our being able to adopt it as the basis of a precise nomenclature. On the other hand, the term local asphyxia, which I had borrowed from Boyer, may give rise to misunderstandings. Objection might be made to the word asphyxia, and yet I believe it expresses an exact physiological fact. A really valid objection would arise to the use of the word "local," if it led to the inference that the malady is *exclusively* local, that is to say, that it is in the affected parts themselves that the origin of the disease is to be sought, which is quite contrary to my view. For all these reasons it would be desirable that this nosological species—for such indeed it is—should be designated by one of those simple words which have absolutely only one acknowledged signification, the advantage of

* *Archives Générales de Médecin*, Jan., 1874.

which Trousseau was so fond of setting forth. Provisionally, and not to complicate matters, I will continue nevertheless to use the term "local asphyxia," asking the reader meanwhile to look upon it as a name and nothing more.

The clinical characters of this singular affection are remarkably constant. I have recently given a summary of them in the article on Gangrene in the New Dictionary of Practical Medicine and Surgery. In the slight cases the ends of the fingers and toes become cold, cyanosed, and livid, and at the same time more or less painful. In grave cases the area affected by cyanosis extends upwards for several centimetres above the roots of the nails; at the same time the nose and the ears may become the seat of analogous phenomena. Finally, if this state is prolonged for a certain time, we see gangrenous points appear on the extremities; the gangrene is always dry, and may occupy the superficial layers of the skin from the extent of a pin's head up to the end of a finger, rarely more.

That which gives to this malady its special feature is the remarkable symmetry which the lesions manifest, symmetry such that when, for example, a single digit is affected on one side, its corresponding digit on the opposite side is also affected, and almost always nearly to the same degree. This interesting peculiarity, taken in connection with the intermittency of the attacks in many cases, would in itself justify the belief that there exists no material obstacle to the course of the blood in the arteries. This presumption is confirmed by the examination of the arteries so far as it can be made during life; and they have been found healthy.

Thus I have been led to enunciate the hypothesis of a contraction of the terminal vascular ramifications, varying from a simple diminution of calibre up to the complete obliteration of the lumen of the vessel. To the total closure of the arterial and venous vessels would correspond an exsanguine and cadaveric state of the extremities very analogous to that which is observed in frost-bite, whilst the arterioles only being closed and the venules open one would see a venous stasis produced by failure of vis a tergo, whence the cyanosis and livid aspect which are seen in the majority of cases.

To attribute these phenomena to a fault of vaso-motor innervation, was an interpretation which physiology assuredly

authorised. I have further maintained that the marked symmetry of the lesions ought to suggest that they originate in a discharge either spontaneous or reflex, starting from the cord and radiating thence to the vascular nerves of the extremities.

But as it is necessary to observe, these explanations were hypothetical, and I have always recognised that a hypothesis, even when it is in harmony with the sum total of the facts which it is intended to explain, ought not to be accepted as a proof until it has been demonstrated. It is precisely this lacuna which I wish to fill up in the pages which follow. It is clear that the theory which I have proposed would acquire a high degree of plausibility if one could demonstrate—

1. That there actually occur in this malady, spontaneous vascular spasms, inappreciable in the great vessels, but very obvious in arteries of small calibre.

2. That it is possible to modify the asphyxial state of the extremities by action from a distance, and especially by acting upon the cord.

This double demonstration will follow, I hope, from the facts which are about to be recorded, and from which I propose to deduce the treatment applicable to local asphyxia of the extremities.

CASE I.—In the month of April, 1872, being judge of a *concours* of the Central Bureau at the Charité, I found in M. Bourdoir's wards, amongst the patients whom I was about to examine, an individual who at once arrested my attention by the dark colour of his extremities, and roused my curiosity by his description of peculiar visual defects, connected, according to his statement, in the most direct way with the morbid state of his limbs. I owe to the extreme kindness of my learned colleague the permission to transfer the patient to my ward at the St. Antoine Hospital, where I had leisure to examine him.

L., aged 59, a journeyman printer, is a vigorous man of a very healthy appearance, and who has never had any other illnesses than intermittent fever contracted in Africa in 1836, and of which he has never felt the effects subsequently. His hygiene is good; he has no excesses; he has never suffered either in regard to his abode or his food. About the month of December, 1871, during a moderately cold season, he per-

ceived with astonishment that the little finger of his left hand became dark every morning. This unusual colour was at first accompanied by so little discomfort that he referred it to the black dye of the pocket of his trousers. Soon the ring and middle fingers of the same hand were also invaded. In the month of January, 1872, the right hand was attacked in its turn. Then, finally, it was the turn of the feet. The symptoms continued to increase up to the month of April; they became sufficiently intense to absolutely prevent the patient from using his hands in his work, and to render his walking extremely difficult. The sight troubles began to manifest themselves towards the month of February. The following was the condition of the patient, according to our careful observations, during the first fortnight of May:—

The affection from which he suffers exhibits intermittent attacks without any kind of periodicity. The attacks recur principally when the patient goes into the air, or when he bathes his hands in water of the temperature of the ward; they appear very often without any appreciable cause. Their duration is variable; it is ordinarily from one to two hours.

In these attacks the two hands, especially the left, assume a livid tint, either violet or blackish, which extends up to the wrists; the tint is almost uniform and without marbling; the pulp of the fingers is completely bloodless except in the two thumbs.

On pressing somewhat firmly with the fingers upon any point of this cyanosed skin, a dead white spot is produced, which only disappears very slowly, a certain indication of the difficulty with which the capillary circulation takes place. The return to the primitive tint extends either from the periphery to the centre, or from a central point which appears in the middle of the white patch, and which little by little, ends by rejoining the border.

In the palms (and they persist during the interval between the attacks) we find indurations situated along the course of the flexor tendons, and they seem to be due to a thickening of the fibrous tissue of the cutis. One experiences on touching the hands a sensation of extreme cold, of which the patient has perfect consciousness. A thermometer held by him in the palm of the hand does not rise above 21·1° C., whilst the axillary temperature is 36·1° C.

There are no spontaneous painful sensations; there are no tinglings; but the sensibility to contact is completely blunted. There results therefrom much embarrassment in movements, the patient not feeling the objects which he holds between his fingers. This embarrassment is increased by the difficulty which he experiences in extending his fingers on account of the rigidity of the skin in the palmar region. The muscular sensibility of the hands is intact.

In the feet we observe the same phenomena a little less marked. There is the same violet colour, the same sensation of cold complained of by the patient. The objective sensation of cold is less pronounced than in the hands. The cutaneous lividity extends as high as the level of the tarsus under the form of marblings indicating the track of the veins. The symmetry in the distribution of this morbid tint is very remarkable; in both feet it is the second toe which is least affected.

The tactile sensibility of the soles of the feet is less blunted than it was. Only a few days ago the anæsthesia was such that it completely prevented walking; the patient was unable to say whether his feet rested on marble or on the flooring. On watching his gait from a distance one would have been tempted to take him for an ataxic; and this mistake was actually made. The other extremities, the nose, the ears, are not attacked.

At the moment when the attack ceases, at the same time that the colour, the heat, and the tactile sensibility return to the extremities, the patient experiences in them a sensation of pricking, painful, but not extremely so. Let us note that the colour never becomes entirely normal on the hands, especially on the left hand.

The careful examination of the circulatory apparatus, both during and between the attacks, gives only negative results. The heart beats are perfectly normal in their rhythm, their intensity, and their tone. The pulsations are perfectly perceptible in the radial arteries, in the posterior tibials and in the arteries of the foot. The arteries are not at all indurated.

Such are the phenomena which we have observed at leisure, and which leave no doubt as to the diagnosis for local asphyxia of the extremities.

Let us now consider what occurred in the eyes, which is the most instructive part of the case.

The patient affirms that his sight is good in the two eyes during the attack, but that during the period which follows, and whilst the fingers return progressively to their normal colour, the sight, especially that of the left eye, becomes troubled and confused, recovering at the moment when a new attack supervenes. He has used for four years a No. 16 convex.

It was of the greatest interest to see if the ophthalmoscopic examination would give the explanation of this singular phenomenon of intermittent amblyopia. It was to be presumed *a priori* that this would depend on disturbances of the circulation in the fundus of the eye. The result of this examination was as follows: the pupil was dilated by atropine. When the left eye (the worse of the two) was examined during a period of reaction—that is to say, when the cyanotic colour of the extremities was at its minimum—we saw that the central artery of the retina, and the arteries which proceeded from it, presented in all their extent very clear contours; further, we established very definitely that they were narrower in their commencement near the papilla than at the periphery. Here and there we observed a sort of partial strangulation. The papilla itself was of a very clear tint. The veins were the seat of extremely remarkable pulsations. We know that pulsation of the central vein of the retina is a phenomenon which is frequently observed in the normal state, and that one can bring it about at will by exercising a gentle pressure upon the globe of the eye; but this physiological pulsation is limited to a very small area at the point of entrance of the vein into the non-transparent parts of the optic nerve. Here we have to do with something quite different; the pulsations are remarkable for an intensity and an extent altogether unusual. They are a little later than the radial pulse. At each pulsation we see the central vein not only dilate and deepen in colour, but elongate itself very notably in the region of its origin in the papilla, so as to simulate a small aneurysm by its expansion in every direction. The pulsation extends well beyond the limits of the papilla. It can be observed in at least three vessels simultaneously, and in almost all the venous capillaries. The right eye (the less affected) presented analogous phenomena, but in less degree. The narrowness of the arteries was certainly less marked than in the left, and the relative diminution of the central artery in relation to its branches less appreciable.

The venous pulsations were observed over a very great extent, greater perhaps than in the left eye, but there was no trace of pulsations on the side of the capillaries.

The ophthalmoscopic examination during the period of cyanosis of the extremities furnished less decisive results than the preceding, and presented several material difficulties of observation. Thus the moment of the attack did not always coincide with the hour of the visit. The examination of the eye, when it is a question of establishing and measuring differences of calibre between two arteries, is a delicate operation, and one which requires time. It happened to us more than once to commence this examination during the cyanotic period, and to perceive on finishing it that the colour of the extremities had changed. This, however, is what resulted from the examination:—

During the duration of the attacks the venous pulsations persisted in both eyes; nevertheless they were much less marked in the left than in the right. The arteries did not recover, as one might have expected, their normal calibre in all their extent. They present partial diminutions of calibre, which in places render them filiform. By patient watching the observer may be fortunate enough to see these contractions form under his eyes, persist a certain time, then disappear, to be reproduced in another vessel.

Guided by theoretical considerations, of which this particular case appeared to me a manifest confirmation, I resolved to attempt in my patient the employment of continuous currents. This treatment was commenced on the 18th May. Electricity was applied for ten minutes daily, descending currents being always used, the positive pole applied over the spinous process of the seventh cervical vertebra, and the negative pole over the lumbar region. The apparatus employed was the sulphate of copper battery of Messrs. Trouvé and Onimus. The number of elements employed was at first 20; it was progressively increased up to 64.

This mode of treatment is very easily tolerated. The patient presented in a high degree a very curious feature, which has appeared to me to be very common, and indeed almost the rule in individuals whose spinal cord is being galvanised in the cervical region when the number of elements employed is from 20 to 30. I refer to a very abundant hyper-secretion of the

sweat glands of the axillary region, a hyper-secretion which only lasts during the time of the passage of the current. The treatment was continued up to the 7th June. We were then obliged to interrupt it for several days, on account of a lymphangitis which occurred, without obvious cause, on the right foot, and which was certainly not due to the electrical treatment, since it had commenced before the currents were used. The use of galvanism was resumed on the 12th, and continued to the 18th. The following is the result of the treatment. From the first employment of electricity an improvement was observed, which became more pronounced each day. After the sixth application the state of the extremities was entirely modified; there persisted indeed a little livid pallor of the terminal phalanges, but the fingers tended more and more to resume their normal colour. When the patient left the hospital on the 22nd June, for more than ten days past the extremities had returned to their physiological tint, all the functions of sensibility and movement had become re-established, and, what is not less curious, the induration of the skin on the palm of the hand, to which I have before referred, had now in great part disappeared.

The restoration of sight had followed a parallel course. At the same time that the extremities became warm the vision became more distinct. I transcribe here some of the results furnished by ophthalmoscopic examination.

May 28.—The venous pulsations are still very markedly appreciable to the naked eye in the region of the papilla; they disappear beyond it. The narrowness of the arteries remains more marked in the left than in the right; one is no longer able to demonstrate any local contractions.

June 7.—Left eye. The veins are generally much larger than on the first examination; but they no longer present any pulsation. The arteries are much larger than they were, and it is to be noted that there is now an ampler blood supply, both to the optic papilla and to the retina in general.

June 15.—The ophthalmoscopic examination of the two eyes reveals nothing abnormal.

It will not be useless to add that the ophthalmoscopic examinations, of which I give the general results, were verified by Dr. Galezowski, who, at my request, had taken part in the investiga-

tion of these phenomena, which are so interesting in regard to the study of the retinal circulation.

Leaving on one side for the moment the therapeutic question, to which I will soon return, the history of this patient may be thus summarised :—

Simultaneous appearance and development, in some sort parallel, of a perfectly characteristic local asphyxia of the extremities, and of visual disturbances manifestly connected with modifications in the circulation of the fundus of the eye ; intermission of these two orders of phenomena with this remarkable feature, that they alternate one with the other ; moreover, both recover at the same time and under the same influence. This relation is so striking that it seems to me to speak for itself.

Hitherto one might indeed have suspected that the local asphyxia was connected with a spasmodic state of the vessels. But whatever foundation there might be for this supposition, as the digital exploration of the accessible arterial trunks did not reveal in these cases anything special, one was obliged to admit by induction a functional trouble localised to the arterioles immediately contiguous to the capillaries. Now here is a case in which the local asphyxia takes place along with an ocular lesion. The two affections are so closely linked that they make in fact only one. The spasmodic contraction of the central artery of the retina can actually be seen. The contraction, I repeat, of this artery, which from its small size assuredly deserves the name of arteriole, takes place under the eyes of the observer. How can it be maintained that it is not an identical phenomenon which occurs in the extremities of the limbs? Here the induction acquires such a certainty that it is equivalent, I think, to a direct demonstration.

But however important may be the result of this observation, it only resolves a part of the question of pathological physiology which occupies us. Spasm of the small vessels exists and causes partial anæmia of the points where these extend ; this partial anæmia manifests itself in the eye by the visual troubles. This position one may consider as established. But under what influence does this spasmodic contraction take place ? It is not sufficient to say that it is due to an anomalous excitation of the vaso-motor nerves, which in the actual state of our knowledge is equivalent almost to a truism. We must be more

precise, and ascertain what are the vaso-motors which preside over the contraction of the central artery of the retina. With regard to this, one might make two hypotheses. We have long known, on the one hand, that besides vascular and calorific phenomena, section of the cervical branch of the great sympathetic produces in the eye remarkable modifications, designated by the physiologists under the name of oculo-pupillary phenomena, and consisting amongst others in a contraction of the pupil, which gives place to a dilatation when one galvanises the upper end of the cut nerve. It is therefore certain that the cervical branch sends sympathetic twigs to the eye, and one may suppose that some of these twigs serve for the innervation of the vessels of this organ. But on the other hand we know also that the fifth pair contains a certain number of sympathetic fibres, which come directly from the encephalon, and which are present in the nerve before its entry into the Gasserian ganglion. The first branch of the fifth pair taking part in the formation of the ophthalmic ganglion, whence arise the ciliary nerves, one might suppose that the vaso-motors of the retina have in reality a cerebral origin.

Between these two equally tenable hypotheses it was impossible to decide *a priori;* it was necessary to have recourse to direct experiment. This I have done, and the former hypothesis I have found to be correct. I divided the cervical sympathetic in several rabbits, and I observed with the ophthalmoscope the vessels of the fundus of the eye before and after the section, taking for standard of comparison the eye of the side not operated on. The result of this observation, considered by itself, might have left some doubt, the veins alone appearing a little dilated. The central artery of the retina did not undergo any very manifest change of calibre; however, the capillary networks appeared a little more full of blood than normal, and one was able to trace the network over a larger area in the fundus than usual. But in order to get a clear idea of the result we must galvanise the upper end of the divided sympathetic. This I did with the kind help of Dr. Moreau. The effect of this galvanisation is as manifest as that which may be observed on the ear of the rabbit. In observing the central artery with the ophthalmoscope it is seen to become narrow by a sort of peristaltic contraction, to grow pale, then to disappear almost entirely, reappearing

when the current is interrupted, and then gradually regaining its original calibre.

It is therefore certain that the central artery of the retina receives its innervation from the cervical branch of the great sympathetic by means of the carotid twigs of this nerve.

This being the case, one is naturally led to seek the first cause of the spasmodic contraction of this artery in an anomalous excitation at the very origin of the nerves which supply it, that is to say, in the cilio-spinal region of the cord. Now we already possess experimental facts which give important confirmation to this hypothesis. I borrow the account of these facts from Dr. Adamiuk, of Cazan, who in the course of his researches upon the etiology of glaucoma was led incidentally to study this question.

He states that if in an animal poisoned by curare the sympathetic centre of the spinal cord, at the level of the two lower cervical vertebræ, be irritated, and if at the same time the eye be examined with the ophthalmoscope, we recognise immediately in the vessels the same distribution of blood which is to be found in glaucoma; the veins are widely dilated, the arteries contracted. This state is not immediately accompanied by an increase of internal pressure, as proved by means of a manometer adapted to the eye; it is only after a little time—more than a minute—that this tension gradually increases little by little. We shall have to return soon to this remarkable contrast between the state of the veins and that of the arteries.

Let us content ourselves for the present with noting the contraction of the central artery of the retina under the influence of the irritation of the cilio-spinal region.

Thus far, as one sees, physiological facts agree well with clinical observation and yield us a satisfactory account of the phenomena observed in our patient. The agreement would be perfect throughout if the troubles of vision due to the contraction of the arteries of the fundus of the eye were synchronous with the cyanosis of the extremities. That there is an intimate relation between these two orders of phenomena is what one would not dream of contesting. Both made their appearance at the same time; they disappeared together and under the same influence. The mind might easily picture to itself a spinal excitation expressing itself simultaneously by vascular con-

tractions in different regions. Unfortunately things do not always come to pass in nature in a way which is most agreeable to our comprehension. In fact we have seen that the cooling with cyanosis of the extremities and visual troubles did not coincide, but alternated with a perfect regularity in such a way that the diminution of one of these phenomena infallibly announced the appearance of the other, and this many times in the same day, and this state of affairs persisting for several months. It is precisely on account of this singular alternation that there was good reason to inquire if the vascular nerves of the fundus of the eye had not an origin entirely different from those of the limbs; in which case one could have better understood a kind of balance being re-established between the bulbar region and the cord, properly so called. One is more embarrassed in explaining this balance, when one thinks of the short distance which separates the cilio-spinal region from the origin of the affected ganglionary nerves which go to the vessels of the upper limbs. I know indeed, and everything demonstrates it, that nerve cells very adjacent anatomically can present a function entirely independent; but in spite of the immense progress made during the last few years in the study of the intimate structure of the nerve centres there are obscurities in the subject before which we are brought to a standstill for the present.

All attempts at interpretation would be here purely hypothetical. It is probable that in other cases we may find local asphyxia and visual troubles coinciding as to time, appearing and disappearing together.

I am now quite prepared to cite an example of it.

Case II.—The patient V., who is the subject of this case, was for a long time under the care of M. Cadet de Gassicourt at the St. Antoine Hospital, where I was able to observe him. He passed thence into the St. Louis under the care of M. Vidal. His history is somewhat complex. He is a young man of 22 years of age, of good appearance, admitted in order to be treated for boulimia with polydipsia, dating back for several months. He eats from 4 to 6 rations daily. He has eaten up to 12 a day. He drinks 4 to 5 litres of liquid, and passes almost an equal daily quantity of water. The urine contains no sugar. One is struck at first with the livid tint which the hands and

face present. This tint, which appears sometimes spontaneously, especially in the morning, shows itself in a marked manner when the patient goes into the open air. It is accompanied by an excessive cooling of the livid portions of the skin. No similar symptoms exist in the lower limbs. At this moment the radial pulse is very small. These symptoms taken altogether constitute a kind of paroxysm the duration of which varies, and which presents no regularity as to the period of its recurrence. The patient complains of some palpitation. There is a cardiac murmur, with the first sound having its maximum at the left border of the sternum in the second intercostal space. V. complains also of experiencing at the *moment of the commencement of the cyanosis a notable obscuration of sight*, which disappears at the time when the face and the hands return to their natural colour. He has been carefully examined by Dr. Panas at the moment when the circulatory troubles have just been developed in their greatest intensity by a prolonged exposure to the open air. At the commencement of the examination a narrowing of the arteries of the fundus oculi is clearly seen. These vessels become widened at the moment when reaction is produced. The retinal veins are generally turgid; they present no appreciable pulsation.

If I give here only an abstract of this observation it is because the multiplicity of the phenomena has introduced into it great difficulties of appreciation. It is infinitely probable that the coincidence in this patient of polyuria and local asphyxia of the extremities is not fortuitous, and that these two symptoms depend on one and the same fault of the innervation of the great sympathetic. But on the other hand there is a cardiac lesion, and this fact suffices to throw doubt on the nature of the phenomena of cyanosis observed in the extremities and in the face. I do not believe for my part that these symptoms are attributable to a blood stasis depending on the heart disease. The proof is that they do not exist in the lower limbs, which, according to this hypothesis, ought to be the seat of predilection; further, they are manifestly influenced by temperature; it suffices in order to bring them out, to expose the patient during a certain time to external cold. I feel, nevertheless, that these reasons, decisive for one who has seen the patient in question, might not convince everybody. On account of the situation of

the murmur one might suspect an anomalous communication between the two sides of the heart. Accordingly from this case I prefer only to deduce the following conclusion: to wit, that the visual troubles complained of by the patient are symptomatic of a contraction of the central artery of the retina, and that these visual troubles coincide exactly with the cyanosis of the hands.

I return now to my first patient, in whom there remains a question very difficult to elucidate; it is that of the venous pulse, so intense and so extensively propagated that it is perceived up to the last ramifications of the retinal veins.

I devoted myself to very extensive researches on this subject, but to detail them would carry me too far from my present purpose, and moreover I propose to publish the results elsewhere.

The existence of a retinal venous pulse, infinitely less, it is true, than that with which we have here to do, is a physiological fact in a sufficiently large number of individuals; in others it is manifested quite easily under the influence of a run, of an effort, of a moral emotion; in everybody one can produce it artificially by exerting slight pressure on the globe of the eye.

Our French authors are almost silent on the cause of this phenomenon. According to Donders, Von Graefe, Stellwag von Carion, the venous pulsations are the visible effect of arterial pulsations, invisible in ordinary conditions. The pulsations of the central artery of the retina transmit to the vitreous body an increase of pressure, of which the effect is concentrated upon the point where the vein passes into the lamina cribrosa. In presence of the difficulties raised by this theory, and notably with the lack of harmony which it presents with certain phenomena observed in glaucoma, I have asked myself if it were not possible to seek the cause of the venous pulsations in a normal anatomical arrangement. We know that the central vein of the retina empties itself into the ophthalmic vein, which itself communicates directly and abruptly with the cavernous sinus, through which passes with a sinuous course the internal carotid artery.

It may easily be supposed that the pulsations of such a large artery could be communicated to the blood column in the veins which meet in the sinus—all the more that this is a cavity with

inextensible walls. These pulsations, transmitted by a kind of eddy, would then manifest themselves in the point where the central vein is sharply bent at its entrance into the ocular globe.

This theory, which I propose with some reserve, would have at least the advantage of satisfactorily explaining the phenomena observed in our patient. The question stands thus: how does it come to pass that the interruption of the course of the blood caused by the spasmodic narrowing of the arteries of the fundus of the eye can determine a colossal exaggeration of the retinal venous pulse? In the normal state, the blood which circulates in the retinal veins, according to the hypothesis which I have just given, is acted upon by two opposing forces: on the one side the vis a tergo, which is simply the impulse transmitted by the movement of the arterial blood itself through the capillaries, and which exercises its action from before backwards; on the other side the intermittent impulse coming from the cavernous sinus, as stated above. Of these two opposing forces, the first evidently overpowers the second, because the direction of the blood current continues from the heart onwards.

Nevertheless to a certain extent they balance one another, and this antagonism regulates the flow of the venous blood in the retina. If the antagonism disappears the one of the two elements which remains exerts an exclusive action. It is precisely this which happens when the excessive contraction of the arteries of the retina annuls the vis a tergo. The blood yields without any obstacle to the impulse from behind forwards which comes to it from the cavernous sinus. Hence arise these pulsations, which affect all the veins of this vascular area, and which make themselves felt even in the capillaries.

Let us further note that the pulsations in question by no means indicate an excessive fulness of the retinal venous system. It is a simple reflux under feeble tension, the capillaries allowing little or no arterial blood to pass in the direction of the heart. It was in fact noted in the case previously described, that when the patient recovered the retinal veins no longer pulsated, but that they appeared much fuller than when the pulsations existed. Before discussing the value of the treatment adopted I will record some other cases fairly comparable with this in many respects.

CASE III.*—Mme. T., aged 52 years, admitted to the St. Antoine Hospital, July 15, 1872.

This woman presents all the appearances of a robust constitution. She menstruated first when 16 years old, was married when she was 17 years, and has had 5 children, all of whom have died. Her life has been marked by pecuniary losses and troubles of all kinds. The catamenia have disappeared for the last five years. Her health has been generally excellent. She states, nevertheless, that twenty-five years ago she was taken with severe pains and sensations of pricking in both breasts; pains and prickings which were not accompanied by change of colour† in the skin, but which the patient compares to sensations which she at present experiences in the fingers.

These symptoms lasted one year, and yielded to the use of a kind of wadding breastplate, which this patient has never ceased since then to wear on the chest. Twelve years ago she was attacked with an eruption on the thigh, probably of dartrous nature. Finally, two years ago she appears to have had an attack of cerebral congestion. Whilst at church she suddenly lost consciousness and became hemiplegic on the left side for two hours. The symptoms yielded to one application of leeches behind the ears. At the end of a few days she was in a condition to return to her usual occupations, and since that time no similar attack has shown itself.

The illness which brought her to the hospital dates from the 1st of October, 1871.

Without any cause appreciable to her she perceived that the fingers of her hands were attacked by numbness and chilliness. Her fingers were, she said, as though they were dead. The insensibility to touch was almost complete; they presented a livid coloration with violet marblings extending up to the middle of the hands. At the end of a fortnight pains were felt in the extremities, which soon acquired such a degree of intensity that they drew from her almost continuous cries. She passed eight days without sleep. The sensation was comparable

* Second Article, p. 189.

† I insist on this fact, because I have observed elsewhere a painful neurosis of the breasts, accompanied by very pronounced lividity; a very remarkable affection, which would merit in some respects the name of local asphyxia of the mammæ, and which has appeared to me to be in relation with hysteria.

to that of a red hot iron drawn over the fingers; these became completely blue.

This severe pain finally disappeared, but the fingers remained livid; at the extremities of all the digits loss of substance occurred, which led to the formation of small dark and depressed cicatrices. At the moment when we first observed this patient (it was in midsummer) the condition of the fingers had been for many months almost stationary. The cold weather brought on recrudescences in the symptoms; the lividity then became still more accentuated. The numbness gave place to a veritable hyperæsthesia, which acquired its maximum in the periods of reaction when the extremities tended to become warm again. For about six weeks there has been in the morning a little tingling in the feet, which otherwise present no modification appreciable to sight.

Besides their colour the fingers of the hands present, especially at their roots, a sort of œdematous puffiness which extends up to the middle part of the dorsal aspect of the hands. The nails have fallen from the index, from the middle, and the ring finger of the left side, from the index and middle finger of the right side. All these lesions are remarkably symmetrical, the parts most attacked on one side are the same as those on the other.

The arterial pulsations are perfectly perceptible and regular in the forearms. No sinuosities or indurations on the course of the arteries can be discovered. The patient states that during the last two months she has experienced a little oppression in the præcordial region. Attentive examination of the heart furnishes only absolutely negative results.

It is needless to add that in this case, as in the last, we inquired with care into the possible causes of gangrene, diabetes, ergotised grain, &c., and that we found nothing of the kind. I ought to say in conclusion that I sought in vain, in this patient, for the visual disturbances to which my attention had been awakened by the preceding case.

The treatment by continuous currents was commenced on the 17th July and contained daily until the 5th of August.

We began the first day by applying for ten minutes a descending current of 30 elements over the vertebral column; the positive pole over the fifth cervical vertebra, the negative pole near the commencement of the cauda equina.

Towards the end of this first application the patient admitted that there was an improvement, feeling the blood, as she expressed it, return into her fingers. We could perceive, in fact, that the tips of the fingers, which were dark before the application of galvanism, became of a leaden white, and that at the same time the terminal phalanges gave to the hand a sensation of less cold. She continued to improve day by day. Each day we saw the colour of the fingers become less and less dark, and grow pale each time after the galvanism. From the 26th July we diminished the number of the elements, which was reduced progressively down to 10. But from this day each application of galvanism to the spine was followed by a local application of continuous currents always in the centrifugal direction, the positive electrode being applied over the brachial plexus, in the axilla, and the negative over the ends of the closely approximated fingers.

The patient could support at first as much as 16 elements employed by this new method of application without experiencing more than a few pricking sensations, which made themselves felt at the end of five minutes. After a few days the extremities of the fingers perceived the passage of a current of 15 elements. Finally, on the 5th of August the patient, completely cured, asked for her discharge, and set out for Chartres, not showing any other traces of her malady than the small cicatrices at the ends of the phalanges.

About a month after her departure she wrote to me that she believed she had again felt some pricking sensations in the fingers, and that she would come to us again if these sensations increased. Since then I have heard no more of her.

Such is the second case of cure obtained by means of the continuous current. In connection with the first it appears to me of a nature to call for the most serious attention of practitioners to this therapeutic measure. It would be absurd to suggest that the improvement obtained was a mere coincidence. In both cases the malady was of several months standing at the time when the treatment was commenced, and seems to have had no tendency to disappear spontaneously. In both cases also the electrical treatment was not complicated by the employment of any other means; it was followed by an immediate improvement. Hence there was no question here of one of those

approximate coincidences which so often leave the mind in doubt when one wishes to estimate impartially the value of a therapeutic agent. The first application was followed immediately by a notable alleviation. This alleviation was greater after the second than after the first, greater after the third than after the second, and so on up to complete cure. Chance is very powerful, but one will acknowledge that it hardly proceeds with this regularity. The following are two additional facts favourable to the employment of the same therapeutic method.

CASE IV.—V., a locksmith, aged 47 years, entered on the 5th November, 1873, the Lariboisière Hospital, under the care of Dr. Panas.

This patient, who has always enjoyed good health, began on the preceding 8th October to feel the first symptoms of local asphyxia of the extremities. The ends of the fingers became cold and cyanosed; the illness continued by attacks which returned every day, and lasted a great part of the day. It soon became impossible for the patient to use his hands, and he was completely prevented from following his trade. On the day of his admission we applied descending continuous currents along the vertebral column. At first the malaise produced by these applications prevented our employing more than 17 elements.

By degrees he became able to tolerate 28. At the very first applications the hands were seen to lose their bluish or black colour, and regain the normal appearance; soon the improvement was maintained during the intervals between the applications.

I saw this patient for the last time on the 17th December, after about six weeks' treatment. At that date he thought he was not in a state immediately to return to his work, but the change was complete. He could easily use his hands for the ordinary occupations of life. The attacks did not return more than three or four times a day, and they lasted little more than an hour. The colour of the extremities tended more and more to become normal.

CASE V.—The patient who is the subject of this case is a young woman aged 22 years, who had never before had a serious illness. She has experienced at times since infancy the phenomenon of "dead finger" in the index of the left hand.

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At the commencement of September, 1872, she was taken with febrile attacks, which lasted fifteen days. Then she had swelling in the two hands, which pitted on pressure.

I accept this statement of the patient because it is not the only case in which I have seen œdema as premonitory phenomenon of local asphyxia in the limbs destined to be attacked. Soon the fingers became completely black up to the roots; dark patches appeared on the nails, the whole attack being accompanied by pains so severe as to deprive the patient of sleep and appetite. There was no affection of the other extremities.

She presented herself as an out-patient at the Lariboisière, where chloroform frictions and pills of sulphate of quinine were ordered for her.

This treatment appeared to produce a real amelioration, because starting from this day the symptoms above mentioned only returned in separate attacks. At the time when this young woman came under my care at the St. Antoine Hospital the attacks recurred two or three times a day; their duration varied from one hour to one hour and a half. The fingers were then black in their two distal thirds, and completely insensible. They remained cold and slightly violet beyond the attacks. Very small cicatrices indicated slight losses of substance of the digital pulp. The fingers presented a remarkably tapering aspect. Some of the nails were deformed. In the cardiac region there only existed an anæmic bruit at the base, with a double murmur in the vessels of the neck.

The treatment by continuous currents was commenced on the 23rd November and pursued up to the 20th December. It consisted from the beginning in the applications every morning and evening of a descending current, the positive pole being placed on the nape of the neck, and the negative applied to the tips of the fingers approximated together. From the beginning the attacks became at once less frequent and less severe; the cyanotic tint of the extremities became more and more limited. At the end of a few days the patient could use her fingers to sew, which she had been unable to do for a considerable time. When she had reached this stage of marked improvement she came to a standstill, and inasmuch as the patient had had intermittent attacks, and as she had derived benefit from the use of sulphate of quinine, I thought it wise to return to the

employment of that remedy. This drug seemed about to cure her once more when she suddenly left the hospital.

I saw her again at the end of some months. The improvement observed had been maintained, but during the last few days the fingers had shown signs of being cyanosed again. I pressed her to undergo the treatment which had benefited her so much before. But she did not reappear at the hospital, and I do not know what became of her. The improvement obtained in this patient was the more worthy of remark since the case was treated at the beginning of the winter, that is to say, at the time of year most apt to aggravate her complaint. What share had intermittent fever in the development of local asphyxia of the extremities in this young patient? That is a question which I find difficult to answer, but I think that as a clinical indication it ought to be taken into account, as in fact it was in the treatment of the patient. Nevertheless this case affords additional experience of the benefit gained by the use of the continuous current. Shall I conclude then that the use of the continuous current constitutes a panacea against local asphyxia and against gangrene of the extremities? Such a contention would be absurd so far as concerns gangrene by vascular obstruction; it would not even be well founded if one applied it to all forms of gangrene without obstruction of vessels.

I had occasion last year to make a fruitless attempt with this mode of treatment in a patient whom I saw in consultation with Professor Richet, and in whom the gangrene of the extremities presented a form and a progress assuredly very unusual. As this fact only touches indirectly on the question which I treat at this moment I content myself with extracting from my notes details adequate for the estimation of the value of the treatment employed.

CASE VI.—This patient, aged 44 years, a native of San Salvador (Central America) came to France in order to be treated for an affection from which he now suffers for the third time. It is eleven years since the first attack, which began without any known cause, and lasted nearly a year. It was characterised by lividity with partial gangrene of the toes of the right foot; it ended by the loss of the last phalanx of the little toe, and of the nails of the four other toes. The left foot only presented during all this time some blushes of redness without pain.

Seven years afterwards a fresh attack occurred, which lasted fourteen months. This time it was the left foot which was invaded. Half the right big toe fell off. The right foot only presented redness and intermittent pains.

Twenty months ago the third attack began, and continues till now. This has presented two periods: a first period of sixteen months, during which the right foot only was invaded and lost its third and fourth toes, and almost all that remained of the fifth; and a second period, which commenced four months ago (May, 1872), and which is now running its course under our observation. At the same time that the cicatrisation is taking place rapidly on the right foot, which was the first attacked, the left foot is attacked, and we see first the base of the big toe (which had been spared in the second attack), and then one after another the four other toes become cold, blue, then black, and present all the phases of mummified gangrene. Nothing can give an idea of the agonising pains which accompanied the work of mortification in this unfortunate patient. He could hardly gain a few moments of sleep by means of enormous doses of opium. All his manner expressed the most acute suffering; he ate extremely little, and wasted considerably. Some indications of the morbid process which has affected the lower extremities have become manifest during the last year in the left hand. The index and the middle fingers have become in different attacks distinctly cold. A minute eschar which was formed at the extremity of the index finger has just become detached. Nothing similar to this has ever shown itself on the right hand. As in the preceding cases, we sought what cause could be invoked to explain these singular phenomena. The patient is not diabetic. Like all his fellow-countrymen he lives habitually on maize, but nothing indicates that he has used damaged maize. None of the persons who live with him have ever experienced similar symptoms. Examination of the heart furnished negative results. The pulsations were perceived in the radial, ulnar, femoral, popliteal and posterior tibial arteries. But it was impossible for us to feel the pulsations of the dorsal arteries of the feet, perhaps on account of the tightness of the skin, and because on the left side the least touch gave rise to pain. I ought to add that it is not without great difficulty that I was able to distinguish the left posterior tibial, of which the pulsations appeared to me very small.

These last circumstances are evidently of a nature to leave a doubt in the mind upon the clinical estimate which is to be made of the fact with which we are concerned.

Although convinced, on account of the excessive slowness and dissemination of the sphacelus, that this lesion depended in our patient upon a purely functional circulatory trouble, I am by no means able to prove that there was no obstruction in the arterioles. But even if one admits as certain the absence of all obliteration, it appears to me very difficult to include this case in the nosological group of symmetrical gangrenes. It is true that both inferior extremities were invaded, but the attacks occurred at long intervals from one another, and differed considerably in intensity. So that in reality there was rather alternation than symmetry of the phenomena on the two sides. This inequality was still more pronounced in the upper limbs, of which only the left suffered from gangrene. For my part, when called upon to give advice as to the treatment to be followed, I was of opinion that one might attempt without risk of harm the use of continuous currents, but without any great expectation of benefit. This treatment was employed regularly during twelve days without leading to the least improvement. I do not enlarge here upon the other therapeutic attempts which were made; everything failed completely, oxygen baths included. Finally, the gangrene was limited by the sole efforts of nature, and the patient, entirely discouraged by the uselessness of remedies, returned to America, not yet cured, at the beginning of November.

I considered that I ought to place this unsuccessful case alongside the facts of recovery which I have recorded above. The latter are, I submit, none the less valuable, just for the reason that the therapeutic indication is related to an order of facts clearly defined to which the history of our American patient presents only a dubious analogy. I ought to add that as regards the intensity of the symptoms, our cases of cure were distinctly slight cases. Would the electrisation of the cord bring about equally rapid ameliorations in those grave cases of local asphyxia of which I have reported examples, and which induce almost at the very onset extensive symmetrical gangrenes? It is at least permissible to doubt it. The best means to avoid disappointment is to guard against exaggerated hopes.

It would be premature with a number of observations so

limited to attempt to lay down in a general manner the rules of treatment by continuous currents. I will mention simply the results of my experience.

At the commencement of the treatment one can generally employ without inconvenience 25 to 30 of Daniell's or Trouvé's elements; nevertheless in one of my patients this number of cells was only attained gradually. The positive pole should be placed on the fifth cervical vertebra, the negative pole over the last lumbar or over the sacrum. When it is placed directly over the level of the inferior part of the cord a very painful sensation of spasm is produced in the lower limbs and in the abdomen.

Applied as I have just said, the current only gives a sensation of heat easily borne. At the end of a few minutes one may gradually slide the negative pole up to the eighth dorsal.

The duration of each application ought to be from ten minutes to a quarter of an hour. A single application each day has appeared to me to suffice, but it may be repeated if required. During the application of galvanism of this strength one observes an increase of the circulatory rapidity, with acceleration of the respiratory movements and abundant perspirations, principally in the axillæ and on the hands. This perspiration ought not to be identified with that which shows itself so often in the case of severe and prolonged pain. Here the pain is nil. We have to do with a secretory phenomenon directly provoked by the excitation of the cord, and which bears witness to an action exercised on the nutritive functions by the current.

Independently of this perspiration directly caused by the passage of the current, I will add that one of the first signs of improvement obtained consists in the establishment of a habitual moisture of the hands, which previously were completely dry. I consider this phenomenon as one of the most favourable elements of prognosis. When this treatment has been followed during some days, and improvement has distinctly commenced, some unpleasant effects begin to manifest themselves—viz., headache (intensified by the passage of the current), painful sensation of constriction of the throat, and general excitement.

Although these symptoms are not serious, it is nevertheless proper to diminish the number of elements employed. We have seen that in one of my cases (Case III.) the number was pro-

gressively reduced from 30 to 10. At this moment the violet colour of the fingers had entirely disappeared; 12 elements then produced a feeling of burning which was tolerated with difficulty.

It is especially when the application of the rheophores over the cord begins to be troublesome that I have found it useful to make a centrifugal current pass through the affected limbs, the positive pole being applied over the nervous plexus at the root of the limb, and the negative pole over the extremity itself. This local application is much more easily tolerated than the spinal one. We have been able to raise the number of elements up to 60 without inconvenience; but 30 elements appear to me in general to suffice for the necessities of practice.

Finally, it is worthy of note that a difference of action is to be observed according as the rheophore is applied over the dorsal surface, or over the palmar surface of the digits. In the first case a smaller number of elements is necessary to produce a sharp pain at the moment of making and breaking. In the second one observes a rather curious phenomenon. At the first moment the current seems hardly to pass, the patient feels nothing; but little by little one sees the needle of the galvanometer deviate more and more, and at the same time there develops a feeling of smarting, which ends by becoming difficult to bear; but at this moment the normal colour of the extremities is already re-established.

This progressive passage of the galvanic current seems to me to be quite easily explained by the greater thickness of the epidermis on the palmar side than on the dorsal, in consequence of which there is a slower infiltration of moisture from the wetted rheophores. However that may be, this direct action of the continuous current on the peripheral circulation constitutes a valuable resource in the treatment of local asphyxia of the extremities. I have never seen it fail, and the change has taken place under one's eyes. Supposing even that the effect may not be always so lasting as I have found it, it would not the less be an element of considerable security to be able, so to speak, at will to bring back, even though it be only transiently, the circulation of the extremities to its physiological conditions. One ought indeed to remember that local asphyxia of the extremities is not only an inconvenient and painful affection, but that it can

at a given moment produce the gangrene and loss of the ends of the fingers. I possess a collection of the ends of fingers thus detached from the hand. It may be hoped that, thanks to the means which I have just pointed out, this sad termination will in future be observed quite exceptionally. Should one renew the galvanic applications a great number of times daily, the distress of the infliction would be largely compensated by the certainty of preventing an imminent gangrene.

After all, the therapeutic action is here in perfect accord with the facts of physiology. If there still exists a certain disaccord between experimenters touching the real action of *induced* currents on the capillary circulation, on the other hand it is well established that *continuous* currents augment the circulation. Messrs. Robin and Hiffelsheim had established in 1861 that the continuous current, when once the circuit is closed, dilates the capillaries, and seems to establish at the same time a regular and uniform circulation of the blood. These results have been confirmed by the very exact researches of Messrs. Onimus and Legros; they are produced whether one acts on the sympathetic nerves, or whether one acts on the skin. Only these skilful physiologists add one condition: it is that the current shall be centrifugal, that is to say, that the positive pole shall be placed on the cord side, and the negative pole on the peripheral side. This condition has always been maintained in our researches.

I call attention very particularly to the fact, which has been very manifest in our fifth case, viz., that on prolonging sufficiently the electrisation of one hand the cyanosis is observed to disappear, not only in that hand but in that of the opposite side, which the rheophores have not touched. This interesting phenomenon denotes between the vaso-motors of the two upper extremities a close solidarity, which can only be established by the intermediation of the cord. This leads us to inquire how the passage of a galvanic current through the spinal cord brings about the diminution, and finally the cessation, of the spasmodic state of the small vessels which determines the local asphyxia? To this question also physiology gives a satisfactory answer. I have no need to recall here the facts which establish that the great sympathetic takes its origin in the central parts of the spinal axis, and that the cord possesses veritable vaso-motor centres,

situated at different heights in its whole extent, centres of which many have been determined with great precision by experimenters. These same effects, which are obtained by section of the great sympathetic, can be obtained by sections systematically made of the spinal cord; upon this point the results of experimentation upon animals can be rigorously applied to man. This is demonstrated by a great number of clinical observations especially collected by Dr. J. W. Ogle* and by M. Brown-Séquard,† in which accidental lesions of the cord have determined the appearance of vaso-motor symptoms, absolutely comparable with the effects of the section of the sympathetic in the celebrated experiments of Claude Bernard. These facts suggested to me to act directly upon the cord in order to influence the peripheral circulation, and the result appears to have justified my expectations. In employing continuous descending currents, I had moreover another reason.

Amongst the effects produced by continuous currents on the spinal cord there is one which has been especially well studied latterly, and to which MM. Legros and Onimus‡ have devoted special attention; whilst the ascending current excites the cord and augments the reflex actions, the descending current hinders the reflex actions and diminishes the excitability of the cord. After having in an animal separated the cord from the brain, when the reflex actions are very manifest, if one makes a descending current pass through the cord one no longer obtains during the whole duration of the electrisation any reflex action, however strong may be the excitation of the posterior extremities. In paraplegics who have presented a great exaggeration of reflex movements, one has been able to moderate considerably the intensity of this symptom by means of currents in a descending direction applied over the cord. This sedative effect of the continuous current is certainly not the only one which one obtains by electrisation of the cord, and I could if there were need, report many observations relative to therapeutic facts which bear witness strongly in favour of a salutary action exercised on the nutrition of this nervous centre.

One might object that in the foregoing examples we have only

* *Med. Ch. Trans.*, vol. xli., 1858.

† *Lancet*, Nov. and Dec., 1868; *Lectures on the Vaso Motors*, Paris, 1872.

‡ *Treatise on Medical Electricity*, Paris, 1872.

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to do with the arrest of reflex movements having to do with external relations, and that the case may be different with regard to the vaso-motor innervation. That is a very improbable supposition; stimuli applied directly to the grey matter of the cord affect in the same way the nerves of movement and the vascular nerves; there is little reason to suppose that the laws of spinal reflection are different for these two orders of nerves. Nevertheless it has appeared to me important not to allow the least doubt to remain in this matter. Everybody knows an experiment, as simple as it is interesting, due to Messrs. Brown-Séquard, and Tholazan, and which recalls that to which I made allusion *à propos* of Case V. When one plunges one hand into water at a very low temperature (from freezing point to a degree above it) one sees the vessels of the other hand contract strongly. The contraction of the vessels of the hand which is not plunged into water commences all the more promptly, and is the stronger, the more severe is the pain experienced on contact with the cold water.

This phenomenon demands necessarily the intervention of the spinal cord; the sensation received by the sensory nerves is transmitted to the excito-motor centre, and provokes in return a stimulation of the vascular nerves, which stimulation produces its effects principally upon the hand which is plunged in water, but also very distinctly upon the opposite hand. There is evidently then a phenomenon of reflex nature. After having repeated this experiment, I have modified it in the following manner, whilst operating either on myself or on several pupils who have been so good as to assist me in this matter. A current of 25 to 30 elements is applied over the vertebral column. By the aid of a commutator it is easy to get either a descending or an ascending current. The subject under experiment bathes one of his hands in water of the temperature of melting ice, whilst the other remains in the free air, and one examines carefully the state of the vessels before, during, and after the passage of the current.

This experiment is very delicate, and it is not so easy as one might believe to appreciate the changes of calibre of the vessels. I have repeated it many times. The result which has appeared to me most marked is the exaggeration of the reflex vascular contraction under the influence of the ascending current. The

inverse effect, that is to say the diminution or suspension of this contraction under the influence of the descending current, this effect I say being negative is more difficult to establish; it appeared to me, nevertheless, that the narrowing of the vessels became more pronounced after the interruption of the current, that immediately after the interruption the veins of the back of the hand contracted visibly.

The passage of a descending continuous current therefore had for its effect the suspension, or at least notable diminution, of the reflex movements placed under the control of the vaso-motor nerves.

This experiment, taken along with the therapeutic effects obtained by the same agent in the treatment of local asphyxia of the extremities, fairly suggests that in this case also electricity acts in the same way, viz., that it diminishes the reflex contraction of the vessels by weakening the excito-motor power of those parts of the cord which govern this exaggerated contraction.

Hence applying the adage, "The cures of diseases set forth the nature of the diseases," I arrive at this proposition, which is only the expression of the facts observed, that is to say, that in a certain number of cases, and perhaps in all, the permanent vascular contraction, which is the dominant phenomenon of the malady in question, is of reflex nature.

One question only remains: What is the sensory origin of this reflex contraction? Probably there are many such points of origin. It has appeared to me in several cases that it ought to be sought in the genital apparatus of the female. But more commonly the peripheral excitation appears to consist in the impression produced by temperature upon the cutaneous nerves. We have almost always seen the symptoms notably exaggerated by exposure to cold air, or by immersion of the hands in cold water.

Only whilst in the normal state exposure to very low temperatures for a considerable period are necessary for the production of more or less analogous effects; in the malady which now occupies our attention an insignificant difference of temperature suffices to produce symptoms comparable with the most intense numbing of the fingers. One may see them appear, for example, in midsummer, when from a room at 18° C. the

patient passes into the external air, at a temperature 11 or 12 degrees above zero.

To sum up in a more definite form, I would say that in the present state of our knowledge local asphyxia of the extremities ought to be considered as a neurosis characterised by enormous exaggeration of the excito-motor energy of the grey parts of the spinal cord which control the vaso-motor innervation.

In conclusion it will be useful to summarise the main points of this paper.

(1) The existence of a spasm of the small arteries, as proximate cause of the local asphyxia of the extremities, had been admitted on inductive grounds. I have reported in detail a case of very remarkable coincidence between the peripheral circulatory troubles and identical phenomena observed with the ophthalmoscope in the retinal circulation, which phenomena have become manifest clinically by an intermittent obscuration of vision, a condition which we ought henceforth to look for in the symptomatology of this affection. This observation furnishes important confirmation to the theory of vascular spasm.

(2) I have thereupon discussed the question of the relations existing between the contraction of the central artery of the retina and the pulsations of the corresponding vein, and I have suggested a new theory as to the mode of production of these pulsations.

(3) I have reported the favourable results of the treatment of local asphyxia of the extremities by continuous electrical currents, showing the possibility of preventing by this treatment the consecutive gangrene.

(4) The electrical treatment consists in the employment of descending currents, applied either over the vertebral column to act on the spinal cord, or over the extremities themselves. Although the first method employed alone has furnished me very satisfactory results, I prefer in practice to use the two methods combined.

(5) The action exercised by the current on the cord appears to consist in an enfeeblement of the excito-motor power, whence there results a corresponding relaxation of the reflex vascular contractions.

(6) This mode of action of continuous currents leads us to think that local asphyxia of the extremities is essentially a

neurosis characterised, as I have just said, by increased irritability of the central parts of the cord presiding over vascular innervation.

(7) Whatever may be the theory of it, local asphyxia of the extremities, considered up to the present as a simple pathological curiosity against which art had no resources, is a morbid condition which is now amenable to therapeutic measures.

APPENDIX BY THE TRANSLATOR.

A FEW words may be added by way of postscript to Raynaud's Memoirs on some of the additions which have been made to our knowledge of the disease in question, especially since Raynaud's final utterances.

Several cases of spontaneous symmetrical or asymmetrical gangrene, arising independently of obvious vascular obstruction, have been recorded in English and American medical literature. One of the most striking examples was a carefully reported case by Dr. Myrtle, under the title of Anæmic Sphacelus (*Lancet*, i., 1863, p. 602).

But Raynaud's researches were first brought prominently before English readers by Dr. Southey, in the *St. Bartholomew's Hospital Reports* for 1880 (case of symmetrical gangrene), and about the same time by Mr. Hutchinson in his Hunterian Lectures at the College of Surgeons.

The subsequent papers of Dr. Southey (case of local asphyxia, symmetrical gangrene, *Trans. Clinical Society*, xvi., 1883, p. 167; case of symmetrical gangrene, *Trans. Pathological Society*, xxiv., p. 286; of the Translator (three cases of Raynaud's disease, *Trans. of Clinical Society*, xvi., 1883, p. 179; and sequel, *Trans. of Clinical Society*, xviii., 1885, p. 307); of Dr. Colcott Fox (*Trans. Clinical Society*, xviii., p. 300); of Mr. G. H. Makins (case of spontaneous gangrene of toes in a child, *St. Thomas's Hospital Reports*, vol. xii., p. 155), and of several other English and American observers, have made the clinical features of this group sufficiently familiar.

Is there anything of importance to add to Raynaud's delineation?

I. The most noteworthy addition is the association of intermittent hæmoglobinuria with some of the cases of local asphyxia and symmetrical gangrene.

There is a suggestion of this association in the history of a case recorded by Mr. Hutchinson so far back as 1871.* A woman, aged 30, had suffered during the winter with frequent shivering fits after exposure to cold. These attacks were accompanied or followed by general malaise, and the urine often became dark after them. One cold day after returning home, she found that her nose and left ear were quite black. During her stay in hospital small superficial sloughs gradually separated from the above-mentioned spots. She was liable to slight shiverings, during which she got icy coldness and purple congestion around the sloughing patches, but no blood or colouring matter appeared in the urine.

Mr. Hutchinson, in commenting on the above case, was inclined to the view that the history pointed to hæmatinuria, and that this and the limited localised gangrene of extremities, in the absence of malaria, had a common origin in exposure to cold, the patient's idiosyncrasy being taken into account.

In 1879 Dr. Wilks† had a boy aged 16 under his care, who, in consequence of some injury to the hip, had had profuse suppuration from the bursa between the glutæus maximus and the great trochanter. The patient, when transferred to Dr. Wilks's care, was cyanotic, and had a systolic murmur at the third right space. The edges of the ears became very blue, and the nose and toes likewise, but the tips of the thumbs and of several fingers became affected with definite gangrene, from which they slowly recovered.

The urine was at different times dark in colour, and gave the guaiacum test; granular casts and *débris* were present, but on several occasions no blood corpuscles could be found. At a later period, however, some blood corpuscles were present.

In Dr. Southey's first case‡ there was a history of the patient having passed black urine with some of her attacks, in which the fingers became numbed, black, and dead; but during her stay in hospital with symmetrical gangrene on the legs and attacks of local asphyxia of the fingers, though a trace of albumen is

* *Medical Times and Gazette*, 1871, vol. ii., p. 678. Gangrene of tip of nose and part of ear; iridoplegia.

† *Medical Times and Gazette*, 1879, vol. ii., p. 207.

‡ *St. Bartholomew's Reports*, xvi., 1880, p. 15.

noted as being present in the urine, there is no record of hæmoglobin.

In Dr. Southey's second case* of local asphyxia and symmetrical gangrene, there was for several days a true intermittent hæmaturia, provoked apparently by impressions of external cold to the surface of his body. It is noted that the blood was usually very apparent by its dark colour, and the obvious sediment it gave, *but its presence was at times only detectible by the guaiacum reaction.* Oxalates either preceded or accompanied the hæmaturia usually. It seems probable that this case was at times, at all events, one of hæmoglobinuria.

In one of the cases recorded by the translator,† the onset was marked by epigastric pain, and hæmoglobinuria was observed to occur within one or two hours from the beginning of the local asphyxia of the limbs. The dark urine only appeared once after a given attack. It gave the reaction with guaiacum, and presented under the microscope pigment and oxalates, but no blood corpuscles. The urine gave the spectrum characteristic of methæmoglobin. The translator pointed out the marked parallelism between typical cases of intermittent hæmoglobinuria and cases of Raynaud's disease, strictly so called, in which the paroxysmal character of the local asphyxia must be considered an essential "note" of the morbid phenomena. "They are not in a true sense periodic, but they are both paroxysmal." "Attacks in both affections have a remarkable relation to changes of temperature." "By far the greater number of cases of both are exclusively winter or cold weather affections, and if not exclusively they are primarily so, and if the attacks do not vanish, they notably diminish when the warm weather appears." "In both, the paroxysms may begin with yawning or with vomiting, and the extremities, as I can testify, may in the onset of an attack of paroxysmal hæmoglobinuria become extremely cold and blue." In both, the attacks may be accompanied by some abdominal pain, and both may be followed next day by sleepiness and by a certain sallowness of complexion and of conjunctivæ. It is the rarest event for an attack of intermittent hæmoglobinuria to occur when the patient is in bed, and this exemption also

* *Trans. Clin. Soc.*, xvi., 1883, p. 167.

† Dr. Barlow, three cases of Raynaud's disease. *Trans. Clinical Society*, xvi., 1883, p. 179. Also sequel to above, *Trans. Clinical Society*, xviii., 1885, p. 307.

obtains in the typical paroxysmal cases of Raynaud's disease. The translator also suggested as "worthy of investigation whether any other visceral paroxysmal affection could be ascertained like the temporary splenic enlargement which he had noticed in one of the hæmoglobinuria cases." The analogy of Raynaud's disease with intermittent hæmoglobinuria has been very frankly accepted by the chief English authority on the latter disease, viz., Dr. Dickinson, in the last published part of his work on kidney diseases.*

He holds that the difference may declare itself by little else than the more narrow limitation and the greater intensity of the superficial arrest of circulation in the one case than in the other. "Indeed the two conditions seem so to approach each other and mingle as to make it impossible to make a distinct demarcation between them" (p. 1187).

One of Dr. Dickinson's cases (Ellen Collingbourne), *vide* p. 499, is most important as bearing on this point, because the history of the case whilst under observation in the hospital shows that the typical attacks of intermittent hæmoglobinuria were on one occasion replaced by a typical attack of paroxysmal local asphyxia affecting one hand, and unattended with the usual urinary affection.

Dr. Druitt† in the account of his own case shows that he suffered from obvious ague attacks, and also from distinct attacks of hæmoglobinuria, related to cold, exposure, and to worry. These attacks were associated with very marked proneness to numbness, tingling, and blueness of the extremities, the blue patches at times being almost suggestive of imminent gangrene.

Dr. John Abercrombie‡ observed in one case that in certain attacks of local asphyxia, affecting chiefly the hands, the child passed urine which was of sp. gr. 1023, and contained about $\frac{1}{10}$ of albumen. It gave the guaiacum reaction, and microscopically oxalates, and some amorphous material were found, but no blood corpuscles.

Dr. Abercrombie holds that we are warranted in believing that

* "Renal and Urinary Affections," Part III. *Miscellaneous Affections of the Kidney and Urine*, 1885, p. 1185.

† Two cases of intermittent hæmatinuria. *Med. Times and Gazette*, April 19, 1873.

‡ "On Some Points in Connection with Raynaud's Disease." *Archives of Pediatrics*, Oct., 1886.

paroxysmal hæmoglobinuria and Raynaud's disease are the same thing, *i.e.*, that hæmoglobinuria is a symptom of the more general affection. He suggests even that the jaundice sometimes found after attacks of hæmoglobinuria (and also after attacks of local asphyxia) is the result of arterial spasm of the hepatic vessels.

The view which would now probably find more acceptance, is that the discoloration is a hæmatogenous jaundice, due to the breaking up of hæmoglobin in the blood stream elsewhere.

Several observers have pointed out that during a paroxysm of intermittent hæmoglobinuria, blood drawn from a cold extremity shows marked changes in respect to the corpuscles. They do not form rouleaux, and are markedly crenated, and granular masses appear in the surrounding serum. Murri,* of Bologna, believes that there is corpuscular destruction in the superficial vessels in which stagnation has occurred, and that arterial spasm, whatever its cause, is an essential factor in the disease. He holds that the corpuscles are broken up by the combined action of cold and carbonic acid.†

Boas‡ found that corpuscular changes could be brought about in the blood drawn from the finger of a patient who was the subject of paroxysmal hæmoglobinuria, by plunging the finger for a time into a dish of iced water; and Fleischer§ found that in one of his hæmoglobinuria patients a blister, which had been applied to the skin during an inter-paroxysmal period, gave evidence of the presence of hæmoglobin in its serum, after a paroxysm of hæmoglobinuria had occurred.

In the above observations no special regard has been made to the occurrence of local asphyxia of the extremities, but Dr. Myers‖ has recorded a case which completes the group in the sense that there are blood changes, local asphyxia of extremities, and intermittent hæmoglobinuria occurring in the same patient.

A boy, aged 12 years, who was under the care of Dr. Cavafy for paroxysmal hæmoglobinuria, dated his first attack five years back when recovering from measles. About the same time, or

* *Dell Emoglobinuria da freddo.* Bologna, 1880.

† Quoted from Dickinson. *Vide* also lecture by Dr. Stephen Mackenzie, *Lancet*, 1884, i., p. 156.

‡ *Deutsches Archiv für Klinische Medicin*, 1883, p. 355.

§ *Berl. Klin. Wochenschrift*, 1881. No. 47, p. 694.

‖ *Trans. Clin. Soc.*, xviii., p. 336.

soon after it, the ears were noticed to be very much cyanosed when the boy was chilly, and they ached much as he got warm. Subsequently gangrene of both ears set in, and this relapsed several times in successive winters. During the last two years the gangrene had stopped, but there was extreme cyanosis, tenderness, and aching of the ears on exposure. The attacks of paroxysmal hæmoglobinuria had continued, being more frequent in winter than in summer. The attacks were typical in every respect. The blood was examined during the attacks, being taken from the cyanosed ears and from the hands. "The coloured corpuscles were fairly normal in outline, but sometimes had crenate edges; there was always an abnormal disinclination to form rouleaux, as Boas and others have noticed. Blood 'flakes,' as they have been called, were found, varying in colour from a deep reddish black to a thin transparent red, and in size from about four to ten times as large as a normal coloured corpuscle."

"On one occasion they seemed to be contained in a transparent envelope, and to be themselves somewhat granular, shading off into the colourless envelope."

II. With respect to the skin: (1) Although chilblains properly so-called are rare in Raynaud's disease, there are some cases of localised patches of subcutaneous mottling in which the deep purplish colour is permanent for a time and then gradually clears up, with or without pigmentation, which have a close connection with local asphyxia and symmetrical gangrene. Perhaps also the cases described by Dr. Cavafy (*Clinical Society's Transactions*, xvi., p. 43), as "symmetrical congestive mottling of the skin" are examples of an allied condition. Of the cases to which Dr. Weir Mitchell has applied the name of erythro-melagia, or the "red neuralgia" (vide *American Journal of Medical Sciences*, July, 1878, on "A Rare Vaso-Motor Neurosis of the Extremities") there are certainly some, which are examples of Raynaud's disease.

(2) Urticaria has been observed by Dr. Southey in one case to occur in the paroxysms of Raynaud's disease, and the same skin affection has been observed by Dr. Dickinson, Dr. Stephen Mackenzie, and Dr. Forrest in paroxysmal hæmoglobinuria.

(3) There is a considerable number of observations bearing on the relationship of local asphyxia, symmetrical gangrene of

extremities, and scleroderma recorded by Ball, Vidal, Favier, and others.

Ball's case, reported by him as a new variety of scleroderma (*Bulletins, &c., de la Société Médicale des Hopitaux de Paris*, 1872, p. 59), was that of a woman who for five years had suffered during the winter from hard yellowish patches on the extremities of the fingers, which subsided with the return of spring. Ultimately the fingers were permanently altered in that the extremities became cold, hard, somewhat unsensitive, and decidedly atrophied. The last phalanges were contracted in a state of semiflexion. The lesions were symmetrical, all the fingers of both hands being affected, but the thumbs were intact. Subsequently the toes were similarly affected. The patient was liable to crises from time to time, during which the finger reddened and became painful, then ulceration occurred and tardy cicatrisation with loss of substance. After each crisis the affected finger became a little more atrophied and deformed than before. There was no trace of scleroderma in other parts of the body.

This case was claimed by M. Raynaud as an example of the chronic form of local asphyxia and symmetrical gangrene. Dr. Colcott Fox states that in two of his cases of scleroderma, in which the hands were involved, the patients had been long subject to dead fingers, and one of them continued to have mild attacks of asphyxia of fingers after the onset of the scleroderma.

A very valuable case has been recorded by Dr. Finlayson (*Medical Chronicle*, vol. i., p. 316). The patient was a mason, aged 36, who presented well-marked scleroderma of hands, feet, legs, front of chest and abdomen, neck and face. This patient was much influenced in regard to the hardness of the skin by exposure to cold. He ultimately developed gangrene of fingers and toes, for which no gross lesion was found to account post-mortem.

In an unpublished case under the care of the translator the order of events was the reverse of that which obtained in Dr. Finlayson's case. A lady suffered for a considerable period with attacks of local syncope of the finger ends, which culminated in symmetrical gangrene of the tip of each index finger. From this she recovered, but afterwards slowly drifted into a state in which the fingers generally presented the atrophied tapering parchment-like character described by Raynaud, with some con-

tractions of the last phalangeal joints, whilst the chest walls became decidedly sclerodermatous.

III. With respect to the joints and structures surrounding joints, Raynaud has referred to fibrous anchylosis of the terminal phalangeal articulations and to thickenings along the processes of the palmar fascia in some of the cases, and the remarkable way in which especially the palmar thickenings may clear up (*vide* New Researches, p. 160). This was strikingly illustrated in an unpublished case under the care of the translator. But it would appear that occasionally the larger joints may become temporarily involved. Thus in Dr. Southey's second case (*Clin. Trans.*, xvi., p. 174), whilst under observation, effusion was noted to occur during one of the attacks in both knee-joints. No details are given as to the duration and character of the joint affection, but in the remarkable case recorded by Dr. Weiss ("Ueber Symmetrische Gangrän," *Wiener Klinik*, Oct., Nov., 1882) there is a long series of observations on these points. In the early attacks only the finger joints suffered, but subsequently the left knee, the right elbow, the right shoulder, and the right wrist were affected.

Weiss thus sums up the clinical characters observed:—There was effusion in joint cavities, and infiltration of connective tissues above and below the joints. Once there was synovitis of the metacarpo-phalangeal joint of the right middle finger, followed by tenosynovitis of the flexor tendons of this finger. On one occasion there was effusion into the knee-joint, associated with exudation into the cellular tissue of the thigh and knee. Sometimes the joint effusion was preceded by pain, in other cases it was painless. The swollen joints and the swelling of the soft parts were not specially tender to pressure. The skin was only reddened once, viz., in the case of effusion into the shoulder joint. The temperature was not raised at the outset, and the course throughout was afebrile. In most cases absorption was rapid, and the constituent parts of the joints returned completely to the normal state. Weiss is inclined to bring these transitory joint affections "into line" with the benign forms of arthropathy described by Charcot and others as occurring in many cerebro-spinal diseases, looking upon the central affection in his case as a temporary anæmia of the hypothetical trophic joint centres in the cord.

IV. *Eye Symptoms.*—No further definite example of amblyopia alternating with attacks of local asphyxia in limbs (as in Case I., New Researches, p. 155), or coinciding with such attacks (as in Case II., p. 164), has been recorded. But Weiss's case, to which reference has already been made, presented some remarkable eye phenomena, referred by him to the involvement of the cervical sympathetic. These phenomena occurred in attacks which were interposed between some of the frequent seizures of symmetrical gangrene of the fingers, and although these attacks had special features, there were other points in which they conformed to the usual order of events. For several days the patient had retraction of the eye-ball, narrowing of the palpebral fissure, contracted pupil with no reaction to light, and a slight degree of ptosis. There was at the same time reddening of the zygomatic region and of the external ear of the same side, some elevation of temperature, and some hyperidrosis. As the attack cleared up, a slight degree of superficial gangrene of the skin of the zygomatic region appeared in the shape of some small patches of first brown then blackened epidermis, which ultimately separated. The patient had several such attacks, affecting the left side of the face and left ear, and some also affecting the right side, and at times both sides simultaneously, but only on the left side were the eye phenomena marked. On the left side of the face there remained subsequently a slight degree of atrophy.

Weiss was inclined to explain the eye phenomena by some central cause, *e.g.*, ischæmia of the cilio-spinal region of the cord.

In Mr. Hutchinson's case, mentioned at the outset of this appendix, of gangrene of the tip of the nose and tip of the left ear, there was also iridoplegia on the left side. The pupils were large and unequal, the left being bigger than the right and motionless, both on exposure to light and on accommodation efforts. There was contraction to Calabar bean, and the vision was good. Syphilis was suspected in this case.

V. *Cerebral Symptoms.*—Some of Raynaud's cases were markedly hysterical and chlorotic (VIII., IX., pp. 43, 54), and one of them (XIX., p. 89) was admitted to the Salpêtrière on account of "epileptiform attacks, with notable alteration of intelligence and incoherence of ideas."

In Dr. Southey's third case, a boy aged 9 (*Clin. Trans.*, xvi.,

p. 167), there were curious maniacal attacks in the early part of the illness, when gangrene of one finger tip was already present.

Dr. Southey has informed the translator that he has since the publication of the above seen several examples of Raynaud's disease in "asylum cases," and Dr. Wiglesworth's case (*vide postea*), in which the disease occurred in a young woman who was the subject of epileptic dementia, is another illustration of this. In an unpublished case under the care of the translator the patient, a middle-aged woman, during a slight remission of her attacks of local asphyxia, became the subject of delusions which were always worse in the evening. The possibility of her requiring to be removed to an asylum was considered, but she ultimately made an excellent recovery.

In Weiss's case there occurred during one phase of the illness a period during which the patient had markedly ataxic aphasia, without any paralytic manifestation whatever. For other cases in which Raynaud's disease occurred in patients who were suffering from grave organic disease of the nervous centres, *vide* next section.

VI. *Pathology and Etiology.*—Consideration of his later examples, and of others akin to them, shows that some of the points upon which Raynaud laid great stress in his early typical cases cannot be maintained in an absolute sense. Amongst these points are (1) the bilateral symmetry, (2) the successive stages of the affection, (3) the depth of the gangrene. There have been several undoubtedly paroxysmal cases in which some of the attacks were bilateral and others entirely *unilateral*. The stages of the affection in a given case are not always as Raynaud stated them—viz., first local syncope, then local asphyxia, then gangrene. Several cases have been observed in which there was no stage of preliminary ischæmia, but in which the local asphyxia was the first event. Finally the gangrene produced has occasionally in cases of Raynaud's type been observed to extend to the deeper structures, and even involve the end of a limb, instead of being limited to the true skin, or the extremity of the ungual phalanx, as described in the text (p. 113).

Relation to Ague.—It is strange indeed that the possibility of any connection between the disease which he described and malarial fevers does not appear to have been considered by Raynaud. In two of his earlier cases (VI. and VIII., pp. 40,

48) the symptoms of local asphyxia of limbs appeared about a fortnight after recovery from tertian ague, and the first of his later cases (p. 155, New Researches) had suffered from ague thirty years previously.

In the article on gangrene (p. 679, *Dict. de Méd. et de Chir. prat.*) Raynaud says that "although after repeated attacks of intermittent fever œdema of the limbs, with or without thrombosis, may often be observed, no examples are known of gangrene special to the malarial cachexia." Since the publication of Raynaud's memoirs several cases of local syncope, local asphyxia, and gangrene have been recorded as occurring in persons who either were suffering at the time or had suffered from ague. The most complete review of this subject has been given by Petit and Verneuil (*Rev. de Chirurgie*, 1883, pp. 1, 161, 432, 699). The cases of gangrene described by them are very miscellaneous in character, some of them resembling the form which occurs as a complication of various exanthemata, and not strictly comparable with Raynaud's type, but there are others which seem to conform to it in that the gangrene occurs in young subjects, and is symmetrical, terminal, dry, and circumscribed. It is also clear that in some of the cases recorded, both of local asphyxia and of gangrene, there was a definite response to the use of quinine. M. Mourson, in his second memoir (*Arch. de Méd. Nav.*, 1880, p. 340) on this subject, places the local asphyxias in malarial subjects in juxtaposition with some of the anomalous central and peripheral nervous affections which occur as sequelæ and "larval" forms of ague, and he broaches the theory of melanæmic deposits in the vessels of the cord, &c., as a possible agent of their production.

It is of importance to note the evidence which has been brought by Dr. Dickinson and others in support of the malarial origin of some of the cases of the allied affection, intermittent hæmoglobinuria.

Relation to Syphilis.—Two of the examples quoted by Raynaud (XVI., XVII., pp. 85, 87) were patients who had suffered previously from acquired syphilis. This has also obtained in some of the subsequently reported cases; and in a remarkable instance of symmetrical gangrene recorded by Dr. Henry Humphreys, the patient was a syphilitic child. The obvious objection arises that in these cases there may have been present some syphilitic

endarteritis capable of causing vascular obstruction; and in future observations this question ought to be carefully investigated. It is noteworthy that both Boas and Murri mention syphilis along with ague as a probable determining factor in the production of hæmoglobinuria (*vide* paragraph I.).

Relation to Peripheral Neuritis.

Raynaud's cases in respect to post-mortem evidence are defective, except in a negative sense, as putting out of question any naked-eye vascular lesions adequate to explain the local asphyxia or the gangrene. The investigations which of late years have been made into the lesions of peripheral nerves have been extended to some cases of gangrene. Whether these cases would have been accepted by Raynaud as clinically conforming to his type is a question; but they deserve consideration. The first was recorded by Mounstein (quoted by Hochenegg, *Ueber Symmetrische Gangrän und Locale Asphyxie*. Vienna, 1886, p. 35). The patient was a man, aged 51, for whom amputation of the right leg in the upper third was performed on account of gangrene of the foot, which had commenced two months previously. A week after the amputation was performed the patient succumbed, with a high temperature. His urine was natural. The gangrene had led to the separation of the first, second, and fifth toes, whilst the third and fourth were isolated; but the skin over all the toes was involved in the gangrenous process as well as that covering the heel, the inner side of the foot, and the dorsum. The vessels generally of the lower extremity were free from abnormal contents; only in the capillary vessels adjacent to the gangrenous focus were microscopic hyaline thrombi present. The posterior tibial artery showed many calcareous plates, but no thrombi adherent to them. The posterior tibial nerve was greatly thickened in its lower part; microscopic investigation showed great wasting of the myelin with collapse of Schwann's sheaths, and chronic inflammatory proliferation of the interstitial connective tissue, especially in the parts close to the gangrenous area. The nerves in the left sound lower limb showed similar changes to those in the gangrenous limb.

The nerve roots of the lumbar region were only affected with neuritis on the right side.

Brain and cord were markedly anæmic, and the examination of the viscera gave negative results.

The clinical history of this case is too meagre to allow of its being definitely placed in Raynaud's group, but the double-sided affection of the nerves, more extensive on the gangrenous side, is very suggestive. The cases recorded by Pitres and Vaillard (*Archives de Physiologie normale et Pathologique*, 1885, p. 106) are given much more fully. The first was that of a young woman, aged 24, of feeble intelligence from childhood, but who at 18 began to suffer from tremors and stiffness of limbs, until at length walking became impossible; the lower limbs passed into a state of extreme contracture, and the patient was bed-ridden and demented. After a time the feet were noticed to be cold, blue, and insensitive; they gradually became gangrenous; the left foot underwent spontaneous amputation, and the right was all but separated. Numerous eschars appeared in various parts of the body; many of these suppurated, and the patient died from exhaustion. On post-mortem examination the tibial arteries were seen each to terminate in a cicatricial *cul de sac*, which was surrounded by fleshy granulations. In no part of the arteries of the lower limbs were adherent thrombi found, only here and there soft clots. The aorta and its branches and the veins of the limbs were healthy, and the examination of the viscera gave negative results. In the nervous system there was found chronic hydrocephalus of the lateral ventricles, and some undue adhesion of the pia mater to the cortex of the hemispheres, and the skull was greatly thickened. There was a slight diffuse sclerosis of the dorso-lumbar part of the cord affecting the whole of the antero-lateral columns and the whole of the posterior columns except their anterior fifth. The spinal ganglia and nerve roots, so far as they were examined, were natural. The principal nerve trunks were carefully examined throughout the body. Those of the upper limbs were normal, and the nerves of the thighs were also normal; the anterior and posterior tibial of both sides presented changes of varying extent, but which were fairly symmetrical. The changes consisted in extensive atrophy of nerve fibres with empty sheaths, presenting numerous nuclei and, at long intervals, varicose dilatations, which contained masses of granular protoplasm and drops of myelin. Between the fibres in many places was found abundance of leucocytes

infiltrated with small granules, and having the aspect of Gluge's corpuscles.

The second case is that of an old woman, aged 56, a rag gatherer, who had been subjected to great hardships, and for six months, along with a sensation of considerable fatigue, had found that in walking she no longer felt the soil on which she trod. Two months before her admission to hospital, bullæ formed on the soles of her feet. These she pricked, and they gave her little trouble. About the same time she began to suffer with obstinate diarrhœa. Three days before admission the feet became swollen, painful, and covered with reddish patches on the dorsal surface. Fresh bullæ formed on the feet; they were perfectly cold, and anæsthesia on the left side extended up to the ankle, on the right side to the middle of the tarsus. The line of separation formed at this level on both sides, but the patient died from exhaustion and diarrhœa before actual separation had taken place. Post-mortem examination showed neuritis of the plantar and tibial nerves, but the vessels of the limbs were natural, and the brain, spinal cord, and viscera were also natural.

The authors of this memoir meet the objection, that in the above case the neuritis might have been consecutive to the gangrenous process by recording the results of an examination of peripheral nerves in a case of gangrene of embolic origin. The nerves in the gangrenous extremities were found to be normal throughout.

Thus Pitres and Vaillard are inclined to regard the peripheral neuritis in their cases as the cause of the gangrene, and they hold that most of Raynaud's cases of gangrene were of like origin.

Dr. Wiglesworth has recently recorded a case of very extensive peripheral neuritis in a woman, aged 26, who was the subject of epileptic dementia and of chronic Bright's disease, and who had suffered repeated attacks of spontaneous grangrene of fingers and toes (*Path. Trans.*, 1887, p. 61).

Hochenegg (*Uber Symmetrische Gangrän und Locale Asphyxie.* Vienna, 1886), whilst admitting the soundness of the conclusions of Pitres and Vaillard on their own cases, disputes the universality of their propositions. He reports a case at considerable length of a man, aged 51, who developed gangrene of the left hand independently of vascular causes. The post-mortem examination

showed chronic hydrocephalus and syringomyelia. In regard to the peripheral nerves only a slight degree of atrophy was found, which was held to be secondary to the cord lesion. Hochenegg maintains that the gangrene was caused by the central lesion, but in view of the existence of the nerve changes, slight and non-inflammatory though they were, this conclusion seems hardly satisfactory.

We must wait for the "last word" which further investigations will justify as to the part played by peripheral neuritis in the *final stage* of Raynaud's disease, viz., that of symmetrical gangrene, and there will still remain the question as to how the peripheral neuritis is itself initiated. But it is safe to assert that *peripheral neuritis alone* is quite inadequate to explain the early and paroxysmal stages of the affection. For the cases which only become manifest during exposure to cold, and which during the intervals return to absolutely normal conditions, no better explanation is yet forthcoming than Raynaud's hypothesis.

VII. *Treatment.*

In the treatment of the cases which go on to gangrene of the limited form which Raynaud describes, the expectant method which he recommends has been repeatedly justified; but with deeper involvement of tissues amputation has been performed with advantage as for other forms of spontaneous gangrene. The use of the constant current, as recommended by Raynaud, has been adopted with advantage by several observers in cases of local asphyxia. The method which has been found most satisfactory by the translator in four separate cases has been the following: immerse the extremity of the limb which is the subject of local asphyxia into a large basin containing salt and water; place one pole of a constant current battery on the upper part of the limb, and the other in the basin, thus converting the salt and water into an electrode. Employ as many elements as the patient can comfortably bear, make and break at frequent intervals so as to get repeated moderate contractions of the limb. In a typical paroxysmal case, if two limbs be similarly affected, it will be found that the limb which is subjected to the above treatment will more rapidly recover than the one which is simply kept warm. It will also generally be found that the patient can

tolerate the above mode of stimulation much more readily than he can bear friction with the hand, and that the use of galvanism in the way indicated, or by simply "painting" with two sponge electrodes, held on the limb at a short distance from each other, will so far diminish the pain that the patient becomes able to bear shampooing afterwards.

In chronic cases, although the relief is not so obvious, there can be no doubt at times as to the value of this measure in improving the nutrition of the limb, and in keeping the threatened gangrene at bay. Even when gangrene in the limited form which Raynaud describes has supervened, galvanism to the parts above and around may be tried with advantage.

Shampooing ought certainly to be employed in conjunction with galvanism, especially in the chronic cases in which the extremity of the limb undergoes a degree of atrophy, or in which contractions and fibrous ankyloses take place. Strange as it may seem, the local application of cold is occasionally more comforting during the painful paroxysms than heat. Dr. Southey found in one of his cases that an ice bag applied over the painful extremity gave considerable relief.

In addition to diffusible stimulants and the whole category of sedatives, nitrite of amyl has been recommended on theoretical grounds with a view to relax spasm of arterioles. The translator tried it many times, both in a paroxysmal case, and in chronic cases, but with only negative result.

REALE ACADEMIA DEI LINCEI, ROMA (1878—9). 276*th Year.*

ON THE NATURE OF MALARIA.

MEMOIR BY

PROFESSORS EDWIN KLEBS AND C. TOMMASI-CRUDELI.

REALE ACADEMIA DEI LINCEI (1883—4).

ON THE

ALTERATIONS IN THE RED GLOBULES IN MALARIA INFECTION,

AND

ON THE ORIGIN OF MELANÆMIA.

MEMOIR BY

PROFESSOR ETTORE MARCHIAFAVA AND DR. A. CELLI.

TRANSLATED AND EDITED BY

EDWARD DRUMMOND, M.D., ROME.

PREFACE.

THE plan which I have adopted in preparing these Memoirs for publication in England has been, first, to make a careful *verbatim* translation of them; and, secondly, as the amount of space assigned to me in this volume did not allow of their being published *in extenso*, to condense and summarize them, which I believe has been accomplished without obscuring the text, or misrepresenting the meaning, of the Authors.

I have to thank the Authors for their courteous assistance in the study of this subject.

EDWARD DRUMMOND, M.D.

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ON THE NATURE OF MALARIA.

CHAPTER I.

PRODUCTION OF MALARIA.—STATEMENT OF RESEARCHES IN THE PAST FOR DETERMINING ITS NATURE.

ENDEMIC malaria has, in the natural and civil history of man, a higher importance than that of all other endemic diseases to which the human race is subject. The latter are met with in more or less limited regions of the globe, but it is, as yet, impossible to define the geographical boundaries of the production of malaria. It reaches its highest point in the tropics, but may be very marked in the temperate zones, and is found even in cold climates. In the northern hemisphere it may originate in all latitudes up to 60° N., and some facts observed in Switzerland by Bergmann tend to show that it may be developed in districts hitherto deemed exempt (the circumstances suggest importation). Hence we cannot at present state what portions of the earth, between the polar circles, may be considered absolutely free. In places liable to it, its production is in inverse ratio to the latitude, and the severity of malarious disease augments in like ratio.

In temperate regions, and still more in the tropics, it may render districts uninhabitable. No other endemic or epidemic is able to do this to the same extent. It constitutes the chief obstacle to the exploration and colonization of the African continent; threatens to reduce to the condition of a desert, vast tracts of the Southern States of America, which were very flourishing so long as they were cultivated by the negro race, which, better than any other, resists its action. In Europe it has desolated whole provinces, populous and flourishing in ancient times. Even where its intensity is not such as to cause

a great annual mortality, it induces a progressive decadence of race, which no other endemic is capable of.

The preservation of society from injurious influences so grave is therefore a socio-economic problem of the first order. The statesmen of all civilized nations have, at all times, striven to get rid of or limit it; and even in semi-civilized Peru, we find water systems, founded and watched by the prudent government of the Incas, in the low lands which skirt the Pacific, in order to increase their fertility and salubrity. In ancient times the Roman rule was pre-eminently distinguished for the vastness and grandeur of the works undertaken to vanquish this public enemy, and such were regarded as among the chief titles of the rulers to honourable recognition by the people. Even in modern times, one of the governments most eminent for civil wisdom and sagacity—that of the two last Grand Dukes of Tuscany—owed its chief claim to renown to the works completed or begun to render salubrious vast malaria-desolated lands. Italy, where malaria has made uninhabitable a great extent of country (chiefly on the western slopes of the Apennines, in Sicily, and in Sardinia), has set herself, since 1870, to the radical solution of this problem, as a great political question. The capital is situated in the centre of one of the most insalubrious regions of the temperate zone, and the soil on which it is built is capable, *in the hot season*, of originating malaria.

The unhealthiness of this season has become greatly less in many parts of the city, owing to the great works of drainage, street construction, &c., carried out during the last nine years, but it exercises, nevertheless, an injurious influence on the development of the city and the public life concentrated there. These conditions of the capital have stimulated research directed to discover the origin of malaria *foci* and the means best suited to limit and extinguish it.

All our knowledge of malarious diseases proves that their true causes must be sought for in the soil of the places chiefly affected, and that the poison, produced in the soil, may be raised to different altitudes by ascending currents of air. *In marshy lands* its production is *nil* or very slight, even when the temperature is very high, *so long as the marsh bottom is separated from the air by a sufficient layer of water*. It grows gradually during the hot season, as the evaporation diminishes this water, and

attains its maximum when a great part of the marsh is uncovered or only separated from the atmosphere by a thin covering of water. There then arises a great quantity of poison which has come to be called by many, even now, *marsh miasm*.

This term ought to be abandoned, because malaria is not developed in all marshy places, and may be abundantly generated in lands which were never marshy. Its production in *non-marshy lands* was supposed to be due to a special chemical and geological constitution—a view chiefly maintained by Heyne and Kirke, but it is untenable.

It originates in soils of very different composition, whilst soils of the same composition, and placed under the same physical conditions, sometimes do, and sometimes do not, produce it. This shows that its development is not bound up with any special chemical composition of the soil, but is insufficient to exclude that, other things being equal, its development may be, more or less, influenced by some chemical quality in the soil. It is not improbable, though it is not proved, that judicious cultivation may so modify the chemical composition of the soil as to diminish its aptitude for originating malaria.

Moreover, the experiments made by Lanzi and Terrigi in 1873,* and repeated by them on a large scale in successive years during the works at the Colosseum,† render it very probable that the addition of lime and its soluble salts to some malaria-producing soils diminishes or suspends this production. It is desirable that such experiments should be made in all malarious soils.

Hygienic researches have hitherto been directed to the physical conditions which favour malaria production in non-marshy lands. All these contain a notable quantity of water in the rainy season, either from their low level or the slight permeability of the subsoil which underlies them. During the hot season this production may take place in the upper strata of the soil when these remain sufficiently damp, as happens in malarious lands covered with woods. If, on the other hand, the ground is uncovered, the summer evaporation may entirely dry the superficial, but does not ordinarily go on to the exhaustion of the lower, strata, which may preserve a remarkable degree of humidity till the return of the next wet season.

* Trans. 11th Congress of Ital. Scient. : Rome, 1873.
† Trans. Academy of Medicine : Rome, 1879.

Malaria cannot originate in these superficial strata, remaining dry, but does so in the wet underlying ones, whenever the air is able to gain access to them through fissures or the porosity of surface soil, or when excavations lay them bare.

In low lands these subterranean foci are sometimes formed by the old marsh bottoms covered by natural or artificial *colmate** (such as, for example, the *cuora*† of many places on the coast or Tuscan Maremma, and the subsoil of most of the Val di Chiana). The subterranean marshes are harmless even when they remain wet during the hot season, if the soil of the *colmata* covering them is deep and sufficiently compact. On the other hand, they generate malaria when only separated from the air by a thin stratum of disintegrated soil,‡ or when the air can reach them owing to excavations or fissures in the overlying soil.

Often, however, subterranean *foci* have no marsh origin, are poor in organic *detritus*, and are found at high altitudes of mountains. The preservation of humidity in lower strata of this sort of soil is chiefly due to the sparing permeability of their subsoil and the irregular inclination of its surface impeding the escape of water. Such are frequent in Italy, and especially in the Roman Campagna and City of Rome, as may be seen by examining a section plan of the aquiferous zone from the Janiculan to the Porta S. Lorenzo past the Pantheon. In such soils malaria is not generated unless the access of air to them is brought about by excavations and other such means. Other hypotheses have been started unconnected with these conditions of soil, and have become sometimes popular traditions. One of the most common is that which attributes to forests the power of generating malaria from the decomposition of the leaves and dead branches which strew the ground. This has been suggested by the existence of many forests in Europe, Africa, India, &c., &c., in which malaria attains great proportions; and because disafforesting has had the effect of rendering many such districts salubrious.

Even in the Pontine marshes an analogous fact was witnessed after the clearing made twenty years ago in the great wood

* *Colmata*, embankment, levelling up of hollow places with earth.

† *Cuora*, equivalent to bog or turf; the carbonized black ooze of marshes resulting from the decay of successive generations of organic materials; a term also used for marsh conduits.

‡ Dr. G. Lindi, Paper read before the Medical Congress at Arezzo, July 10, 1877.

which surrounds the Cisterna country on the south. This wood is that of which Lancisi prevented the felling in 1714, being persuaded that woods ameliorated the air of marshes, and in this case protected Cisterna from the south wind which he believed conveyed the malaria.

On the contrary, the destruction of this great wood has procured for Cisterna a marked increase of salubrity and population.* In spite of this, the explanation is fallacious. The existence of decomposing vegetable *detritus* in a forest is not sufficient of itself to cause malaria, as we see in other parts of the globe vast forests, containing such detritus, which are, notwithstanding, salubrious, as, for example, some virgin forests of South America. It is, however, certain that when woods cover malarious lands, they may favour its production, especially if situated at a level which hinders the outflow of water.

The wood, intercepting the sun's rays, impedes evaporation and allows the malarious soil to retain much moisture during the hot season, *even in the strata most exposed to the action of the atmosphere.*

This obstacle being removed, the consequent summer desiccation markedly diminishes the malaria production, and if the soil be not deep may go so far as to arrest it. One can understand, therefore, how disafforesting alone may increase the salubrity of such places, and how, on the other hand, in deep soils, it cannot arrest malaria without the help of such drainage as may exhaust the water of lower strata which the sun's rays are not able to dry.

It is the opinion of many that malaria may be generated by the decomposition of low organisms, animal and vegetable, which die in large numbers when sea water is mixed with fresh water, collected in its vicinity. This opinion is based on the coincidence that in some parts of the Italian coasts where fresh water ponds are only separated from the sea by dunes, intermittent fevers occur.

This has, however, only been met with where the surrounding lands are malarious; or were so formerly, and appear still capable of becoming such again, whenever the old marsh *cuora* which they contain are placed, in summer, under favourable conditions

* Lancisi, *Unedited Addresses on the Cutting of the Woods of Cisterna and Semoneta.*

of moisture and exposure to atmospheric air. Besides, this coincidence is not observed except in seasons abundantly malarious. At other seasons of the year this mixture occurs so as to determine the death of a very great quantity of animal and vegetable organisms, rendering turbid and fœtid the waters of these coast lakes (*e.g.*, Burano, Fogliano, dei Monaci, Caprolace), without fever showing itself even amongst those who spend whole days in fishing and shooting on them. If, then, the lands adjoining be not malarious, the mixture of salt and fresh water may assume vast proportions without the malaria appearing, as is seen in large littoral lakes of the Baltic (Frisches Haff and Curisches Haff), which do not generate malaria, while it is produced in localities identical as to latitude and climate (Jahdebusen and Wilhelmshafen), which, however—a difference of the first importance—are surrounded by malarious lands.

If, therefore, we have not sufficient evidence to exclude that this mixture may aggravate the unhealthiness of a place, we have enough to show that it cannot, of itself, generate malaria in a healthy locality. The same holds true of the opinion that steeping hemp and flax may evolve malaria. Such become offensive from the putrid effluvia they give off, and from contaminating drinking water, but they do not cause malaria.

Such macerations are largely practised in districts which are not malarious and do not originate fevers in them. This does not prevent the possibility that, when practised in malarious localities, they may aggravate the evil, if in no other way, by the excavations necessary in making the tanks, by which air may be admitted to otherwise harmless infection foci. Certainly every reason of prudence counsels the removal of all concomitant causes of unhealthiness, that nothing tending to amelioration may be left untried. But the essential aim of the latter is that of *modifying the true seats of production—viz., the malarious lands —in such a way as to take from them the possibility of offering a field for the development of malaria.*

Experience has shown that this cannot take place without a combination of three factors:

1. A very high temperature.
2. A persistent humidity of the soil.
3. The access of air to the moist strata of the soil.

When one of these is eliminated development of malaria cannot

take place. Even in malarious districts left to themselves, it sometimes happens that, if the mean summer temperature be very high and no rain falls, the production of the poison is arrested, because evaporation from the soil exhausts all the moisture it contains. The occurrence of rain will, however, determine its development in a few hours. So, also, if the summer mean is very low malaria is not developed, or is confined within narrow limits, but it recovers all its force in a very short period if the temperature of the air is raised. The chief aim of works of amelioration up to the present time has been to effect the removal of one of these factors by drying malarious soils. The necessary hydraulic works have varied according to the quality and level of these.

In low-lying lands, to prevent the stagnation of water in the soil and subsoil, the system of open channels has been adopted, in order to secure at all seasons of the year the escape of water. When the land has a level equal, or nearly equal, to that of the sea or natural collectors of the district, this system has been combined with pumping machines, or with the system of *colmate*, wherever it is possible to introduce watercourses rich in suspended soil to the lands to be ameliorated. The rise of level procured by the *colmate* has the twofold advantage of draining the soil and burying that part of it in which the malaria originates, so that, when successful, this secures the removal of two of the factors.

In lands situated at higher levels, measures have been adopted according to the conditions present—open canals, great collecting pipes, superficial drainage by open canals and earthen pipes, and even drains constructed at a remarkable depth. The most beautiful examples of these last are afforded by the *cunicular* drains, met with in the Roman hills and Agro Romano, where, according to Lanciani, this system reached its highest development in the imperial epoch.*

These methods remove one or two of the external conditions indispensable to malaria production, but do not destroy that special tendency of malarious lands which constitutes the essential difference between them and those which, identical as to chemical composition and surrounding conditions, are incapable

* Lanciani, *Some Works of Amelioration of the Agro Romano, executed by the Ancients.* Also Secchi, di Tucci and others.

of originating this poison. The cause is simply reduced to impotence; but examples are not rare in which, after this has happened, the development has recommenced and attained large proportions when the external conditions, which had been banished, were reproduced. In a district long free from malaria, neglect of the water scheme, inundations, or superabundance of rain, or accidental opening up to the air of some of the old *foci*, suffices to start the malaria again.

The conversion of the Crown domains of the Val di Chiana into private property has led, in a great part of the valley, to neglect of the hydraulic works, allowing a return to the former state, and consequent reappearance of malaria in many places in which there had long been no trace of it.

It is this which has happened in the Agro Romano, which in the imperial epoch had been rendered so healthy as to permit of a summer residence in villas situated in spots now regarded as amongst the most insalubrious in the temperate zone, showing that not even centuries of exemption can ensure that the cause has been got rid of, beyond the possibility of recurrence. This remarkable tendency of malarious lands has stimulated research as to the nature of the agent that produces this effect, in the hope that, this being once known, means might be discovered of destroying it and rendering its development impossible, and thus obtaining a lasting and secure amelioration. The first researches were directed to the examination of the gases diffused in the soil for one capable of generating it, but with only negative results. Again, the supposition that some volatile product of animal or vegetable decomposition might be the cause has not been borne out by facts.

It has never been shown that the mud and air of marshes contain an inorganic substance capable of developing, without the intervention of any other substance, malarious fever.

Moreover, its production, even in marshy lands, is sometimes wanting, although animal and vegetable organisms undergo putrefaction as actively as in those which are malarious; while, on the other hand, malaria may develop in non-marshy lands in which such putrefaction does not occur.

The want of exact correspondence between the quality of the soil and the production of malaria has led some to suppose that such may not be due to a specific cause, but rather the result of

sudden or very rapid lowering of temperature, rendered more injurious by the marked humidity generally found in malarious countries. This opinion has been adopted by even distinguished observers like Santarelli,* and sustained recently by Oldham.† Here the essence of the disease has clearly been confounded with a frequent, but not invariable, cause, *determining development.*

Undoubtedly many persons, so long as they use every precaution against chill, live with impunity in malarious countries, but are seized with an attack if they leave off such precaution, and this even after having left the malarious district.

The same holds good of cholera and other like diseases, and is easily explained by the disturbances of the circulation which chilling brings about in vascular areas, which allow the disease-ferment, already in the system, to fix itself in some part of the body and there display its evil influence. Besides, malarious fevers may arise without the intervention of this cause, as one may easily satisfy himself, especially in places where the graver forms of malaria prevail. On the other hand, in *non-malarious* countries, this cause (chilling), however severe it may be, never originates a malarious fever.

The same reason—viz., the inconstancy of the relation between condition of soil and malaria production—which has led some to reject the idea of a specific cause of infection, has suggested to others that malaria may be due to a parasitic organism which requires for its development not only favourable external conditions, but also the presence of a germ capable of giving rise to it.

Various reasons tell in favour of this hypothesis; among others, certain analogies which are common to malaria and other known parasitic infections, and the augmented production of the former when left to itself. When man's industry ceases to remove the external favouring conditions of malarious production, this assumes such vast proportions as are inconceivable without the existence of an organism capable, when its evolution is no longer checked, of infinite multiplication. This enormous increase is historically proved, especially in Italy.

The Tuscan and Roman Maremma, the Roman Campagna, Pesto, Selinute, had malaria in ancient times, but were inhabited by numerous and prosperous populations; now they are hardly

* Santarelli, *Researches.* † Oldham.

habitable except where man's industry has again been applied to remove the conditions on which malaria depends.

The conception of a living organism which, finding no check to its development, has the power of extension by an infinite number of progressively increasing generations, seems to fit best the magnitude of the phenomena.

The diffusion of malaria, in the air overlying lands which produce it, furnishes some arguments in support of the hypothesis that it is due to the agency of solid particles.

The first hours of morning, and still more of evening, are the most perilous to those who breathe this air; besides, experience has shown that the cause to which this insalubrity is due is often confined to the lower strata of the air, and at a few metres from the ground ceases or notably diminishes. In the Pontine marshes, whilst the effect of sleeping during a summer night, so as to breathe the air nearest the ground, would inevitably cause an attack of perniciosa, people sleep with impunity on a platform raised on piles a few metres from the ground. In South America people similarly circumstanced preserve themselves by sleeping in hammocks suspended from the trees. This is explicable on the supposition that malaria is due to solid particles of slight specific gravity contained in the soil, and raised to a certain altitude during those hours in which the difference of temperature, in the lower strata of air and in the soil, causes an upward current; and that this does not happen, or only in a minor degree, when the two temperatures are almost equal. Were the agent a gaseous one due to chemical action, it should be at its acme in the day hours, when the soil is most heated by the sun's rays.

Not less does the hypothesis that malaria may be due to a volatile substance united with watery vapour, raised with it in the atmosphere during the day and reconducted back to the earth at sunset, afford an explanation of that immunity which is enjoyed at a few metres from the soil.

Lastly, the mists which form at evening in malarious places, and which are often fœtid, from the products of putrefaction they contain, are not confined to the strata nearest the ground.

They may be very thick even at high altitudes, so that in the plains and valleys they appear, in the early dawn, when the sun has not yet appeared above the horizon, like a sea which covers and conceals all, even the church towers.

These considerations, therefore, if they give some probability to the hypothesis of the parasitic origin of malaria, are certainly insufficient to convert it into a scientific theory.

In addition to this it is necessary to show—1*st*. *The constant presence of a determinate organic species in the various kinds of malarious soils and in the air which overlies the same.* 2*nd*. *That this organic species can alone—viz., without the intervention of any other morbific agent—generate a true specific intermittent fever.*

This double demonstration, indispensable to the theory, has not yet been obtained, although for thirteen years researches have been instituted with this object.

In 1866 Salisbury believed he had discovered the cause of malaria in an alga of the genus *Palmella*, which he had found in certain marshes in Ohio.*

He maintained that the spores of this alga, diffused in the air and penetrating within the human organism, produced malaria. In support of this opinion he adduced the fact, that having placed some boxes of earth containing this alga on the window-sill of the room in which slept two young men with the window open, both took intermittent fever in fourteen days. Their dwelling was five miles from the spots whence the earth was taken, but it was not certain that they might not have visited these places and others equally unhealthy.

But granted that the fever in these two persons was due to the earth contained in the boxes, one such experiment was insufficient to prove that it was due to the *Palmella gemiasma* of Salisbury, and not to other organisms contained in the same.

Later, this *Palmella gemiasma* has been found in very healthy places, and even on the Alps, and Lanzi and Terrigi have seldom found it in the stagnant waters of the Campagna, and have never met with its spores in the air of the most malarious places examined by them.

In 1869 Dr. P. Balestra described an alga found by him in the Pontine marshes and in those of Ostia and Maccarese, which he held was the cause of malaria. He described neither its genus nor species; however, Lanzi and Terrigi decided to regard it as *Cladophora* or *Œdogonium*, which abound in these places. In a later edition (1877) Dr. Balestra, without yet determining the

* *American Journal of Medical Sciences*, 1866.

plant, still less stating its exact dimensions, gave two figures of it entitled *Alga miasmatica*, so shapeless that one cannot tell what it was meant for—an alga, a fungus, or some other organism.

The experiments made by Balestra to prove that the plant studied by him was febrigenous do not avail to prove it. He treated some fluids containing it with quinine, arsenious acid, and sulphite of soda in solution, and found that they, especially the quinine, arrested its growth and altered its structure.

It is insufficient to establish such relation between this plant and quinine, as Binz proved long ago that the latter kills a large number of animal and vegetable organisms which certainly have no influence on malaria. In Balestra's experiments the quinine also killed all the infusoria and suppressed putrefaction for a very long time. This author has not sought to show the specific action of this plant by isolating it and procuring intermittent fever by introducing it into the organism. The only evidence of this kind adduced by him is that he was himself seized with intermittent fever, eight hours after having accidentally drunk from a carafe containing marsh mud, on the surface of which a stratum of this plant had formed. When we remember that this happened when he was working during the height of summer in Rome, and making excursions to the Pontine marshes, Ostia, and Maccarese to collect material for study, we cannot but think that the fever might have had another origin; and however ready to admit that it was due to the contents of the carafe, there is no proof that the cause was this particular plant, and not an inorganic substance or one of the numerous other organisms contained in marsh mud. His drawings show this variety of organisms, and along with sporules of this alga, many others besides—small granules like micrococci of Schistomycetes, and also larger bodies and filaments like the germs of Hyphomycetes. Probably the author did not attach any importance to these, as he still believes in the polymorphism of Hallier, and holds that these organisms may pass from the one form to the other without change of nature; but now for many years the works of De Bary, F. Cohn, Näegeli and others have shown the insufficiency of this convenient hypothesis. It is to be noticed finally that Balestra does not appear to have found the plant he believed to be febrigenous in the non-marshy malarious lands of this province.

Safford and Bartlett believed they had discovered the cause of malaria in *Hydrogastrum granulatum*, Archer in *Chtonoblastus aeruginosus*, and Bargellini in *Palmoglea micrococca*, simply because each had found in abundance the plant which arrested his attention in the marshy soil taken for examination; but these three are found abundantly in all soils rich in moisture, while Lanzi and Terrigi have rarely met with them in the soil of the Roman Campagna; besides, these authors observe that the spores of the *Hydrogastrum g.* and *Chtonoblastus a.* are of larger diameter than the capillaries, and it is therefore impossible for them to enter the circulation and cause fever.

Griffini, in 1873, performed experiments on dogs and rabbits with dew collected on the marshes and rice-fields.

This dew contained a *bacteria, vibriones*, some filaments of *leptothrix*, some *spirillum*, and many infusoria of the genera *Monas* and *Cercomonas*.

Injecting it in quantities from 75—100 cc. into the veins of dogs, he obtained after the first injection augmentations of temperature of 0°·6—1°·5 C., which lasted a short time and gradually passed away.

The injection of 100 cc. of water from a rice-field, taken July 16th, into the jugular vein of a dog, produced a temporary rise of 0°·6 C., whilst the injection of 96 cc. into the jugular vein of another dog produced a rise of 0°·5, which lasted three hours and then passed away. In rabbits the injection of dew into the jugular (8—10 cc.) caused the death of the animals after 5—12 hours, without notable rise of temperature. A rabbit, under the skin of which 2 cc. of the same dew was injected, died in 28 hours without having shown any rise, but, on the contrary, a progressive fall, of temperature. A rabbit which was made to swallow 20 grammes of dew, and had 5 grammes more injected *per rectum*, showed from the beginning a rise of 0°·6, but afterwards the temperature fell 2°·5 C. On the second day it died. In none of these animals in which the injection produced a rise of temperature did there follow a second access of fever, and the measurements were too few to determine the type of fever. The spleens were normal, but do not appear to have been examined microscopically. The blood showed no increase of the organisms contained in the dew.

Drs. Lanzi and Terrigi, of Rome, applied themselves to the

study of the subject in 1870, and communicated the results of their first observations to the Medical Section of the 11th Congress of Italian Scientists, October 19th, 1873.

At that time Dr. Matteo Lanzi had by a series of artificial cultivations, instituted with mud collected in certain malarious spots in the City of Rome, and the salt marshes of Ostia and the Pontine marshes, obtained the specimen called *Monilia penicellata*, Fr. (*Briarea elegans*, Corda), and was disposed to consider it the cause of malaria. Later on, however, continuing his researches with the conscientious assiduity which characterizes him, he obtained so many organic species as did not permit him to retain his first opinion, so that he and his colleague Terrigi, fearing to be misled by fallacious appearances, abandoned the parasitic theory of malaria which they had sustained in 1873, and admitted instead that malaria consisted in a *cadaveric vegetable product* generated by putrefaction of algæ and other plants. They undertook, therefore, new experiments with mud from the marshes of Ostia. The hypodermic injection of dogs during winter with Ostia mud (collected during the previous summer) gave rise only to passing disturbances, and in the bodies of the animals no *post-mortem* evidence of malaria was found. The simultaneous injection of guinea-pigs with the same material produced some ill-defined morbid states, and in one of the animals was found, in the spleen and liver, some black pigment. The temperature does not seem to have been taken in the first experiments. The experiments were repeated in the height of summer with mud (August) from the Stagni of Ostia. This was injected hypodermically into two animals—the observers having first ascertained by a few autopsies on healthy guinea-pigs that the blood contained no organisms and the spleen and liver no black pigment.

The first of the two died in 57 hours, after a rise of temperature which reached 40° C., and then fell to 34° and ultimately to 31° C. (axilla). *Autopsy.*—Many bacteria at injection site, spleen and liver enlarged, and containing small quantity of black pigment; a few granules also in the blood of the portal vein.

The second animal died on the thirty-second day; maximum temperature, 38° C.; minimum, 37° C. An abscess, which opened spontaneously on the twenty-second day, formed at the site of injection. *Autopsy.*—Spleen and liver enlarged. Granules of pigment in the spleen and blood of the portal vein. The same

results, with the sole difference of greater amount of pigment, were found in guinea-pigs made to breathe for many hours, in a confined atmosphere, the effluvia from Ostia mud, and in the case of one to breathe like effluvia from decaying grasses collected in August outside the Lateran gate. Parallel to *each* of these experiments another guinea-pig was kept in an equally confined atmosphere containing no effluvia for a like number of hours. None of the animals, in this counter-experiment, showed any signs of pathological disturbances. Each was killed at the same moment as the corresponding animal experimented on, and no trace was found of the alterations met with in those which breathed infected effluvia. Lanzi and Terrigi* have the merit of having used a more rigorous method than any of their predecessors, and of having taken the first step towards the solution of the problem; and the discovery of black pigment shows that *they first* succeeded in procuring malarious infection in animals. As, however, they did not examine the splenic swelling, ascertain the proportionate weight of the spleen to the entire body, or make sufficient thermometric observations to determine the type of fever, the observations are inadequate. Nor did they ascertain if the black pigment contained iron in inorganic combination, which distinguishes the *melanæmic* pigment of malaria from other black pigments (melanin).

It is therefore uncertain whether the fevers were really malarious or were produced by septic infection, all the more as the materials used were rich in putrefying organic matter.

As regards the nature of malaria, these talented observers have only expressed the opinion that its cause is a *cadaveric vegetable poison*—a non-living ferment—but they have adduced no proof, direct or indirect, in support of their opinion; they have not isolated the substance and shown that it can generate malaria; nor were they certain before commencing the experiments that all the organisms were dead.

After the meeting of naturalists at Cassel, September, 1878, we undertook the study of this question in the Roman Campagna in the spring of the following year, and one of us (Tommasi-Crudeli) set himself to study and define the foci of malaria in the extent of the Agro Romano in the course of the winter.

* Lanzi and Terrigi "On Vegetable Miasm, Malaria, and the Climate of Rome," Acad. Med., Rome, 1876.

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CHAPTER II.

METHOD OF RESEARCH.

To achieve the aim of our researches, it was necessary that they should take into account all existing opinions respecting mycotic, and the special peculiarities of malarious, disease; and that these should be dealt with by such rigorous method as should enable us to avoid the *petitio principii* into which some of our predecessors had been led. We had to decide what symptoms and morbid appearances should be regarded as characteristic and establishing the identity of malarious disease artificially produced. This presented little difficulty, as regular intermittency of febrile attacks, enlargement of the spleen, and the special anatomical characters of malarious splenic hyperplasia are amply sufficient for the purpose.

Omitting the so-called "larval forms," we have to consider the febrile states of continuous course which are seen alone or in combination or alternation with the more regular intermittent forms, such as the form of malarious fever seen in Italy, to which has been given somewhat loosely the term "Roman fever." Such differ so materially in their clinical aspects from ordinary intermittents, that some have believed them to be non-malarious, an opinion long since refuted by clinical experience, or as due simply to chill, of which the fallacy was shown in the last chapter.

The opinion that malarious is convertible into typhoid fever is one of which no proof has been adduced, and while it is most improbable that one disease should be converted into another, it is not improbable that the two may sometimes be united and run parallel in the same individual, although this has not yet been demonstrated by an autopsy.

That an intermittent may be converted into a continuous or subcontinuous malaria fever, a fact long known in human pathology, has been shown, by our experiments, to happen in the

artificial malaria of animals.* *A priori*, artificial production of malaria in the latter would seem unlikely, as in malarious districts most deadly to man they appear to enjoy a perfect immunity; and certain diseases and poisons which attack man seem not to affect animals, and *vice versâ*.

Experimental pathology has shown, however, that such immunity is more relative than absolute; and the tubercular and diphtheritic infection have been produced in animals, while one of us (Klebs) has shown that syphilis may be communicated to monkeys.

Contrasting the unhappy condition of man in, for example, the Pontine marshes, with the thriving state of thousands of mammals, there exposed much more completely to malarious infections, it is difficult to explain the immunity of the latter.

The rule, however, seems to have its exceptions, as certain breeds of horses introduced into the Campagna are said to suffer from enlarged spleens; and flocks of goats are said to be decimated in such localities by disease attended with splenic enlargement. Some part of the immunity of animals may be due to acclimatization, just as the negro race resists as no other can the malarious poison, and thrives in tropical lands uninhabitable by the less resistant white races. This may in part be the outcome of natural selection in the hereditary struggle against malaria aggression, and in the long course of centuries animals may acquire a power of resistance to malaria so long as it only reaches them through accustomed channels. The greater extent and tortuosity of the nasal respiratory passages, and the necessity for air laden with malaria germs to traverse such an extent of moist membrane, may, in animals, place them at an advantage in comparison with man, whose respiration, unlike theirs, is chiefly buccal. Experiments might settle this question, but it only falls within our design to secure the introduction, into the circulation, of malaria poison, and to observe if a true malaria fever results. We confined ourselves to the subcutaneous injection of the suspected material, and obtained the positive results set forth in the next chapter.

In order to judge of the precise nature of the fever so origi-

* My experience coincides with that of Sir Joseph Fayrer and others, that a fever, clinically indistinguishable from typhoid, arises in malarious countries, from a cause other than fœcal emanations.—E. D.

nated it is necessary that the temperature should be taken very accurately and often. We, in our experiments, had it taken every two hours from 6 A.M. to 10 P.M., and sometimes also at midnight, at first using a maximum centigrade (Geissler), and when this was broken, a good Roman one—both by a curious coincidence, indicate an error of —0°·1, as ascertained by our colleague Cannizzaro. *In our tables and temperature curves this error requires to be corrected.*

The weight of the animals was carefully ascertained before commencing the experiments and during their course. At the beginning of malarious fevers, especially the intermittent, there is slight increase of weight; but later on, and particularly in the continuous forms, there is loss, and often rapid loss, of weight. *This point is of very great importance.*

In malarious infection naturally occurring in man and artificially produced in animals there is enlargement of the spleen, from hyperplastic tumefaction, with *uniform increase* of *all* its dimensions without loss of sharpness in its angles and borders. In septicæmic enlargement the organ is uniformly rounded and altered in sectional outline. The method which we adopted to record the size of the spleen was a species of "*nature printing.*" The convex surface of the spleen was smeared with blood and applied to sized paper to obtain an accurate print; afterwards the transverse section was so taken. In this way we obtained the figures in Table I.

Another characteristic of malarious affection is the production of black pigment of hæmic origin, which is not only found in perniciosa, but in milder and more chronic intermittents. In severe forms it is produced in great abundance, and is met with in the blood, spleen, and bone marrow. Unlike *melanin*, it contains iron in inorganic combination, and treated with hydrochloric acid and ferrocyanide of potassium produces Prussian blue. Its derivation direct from the blood is now ascertained. No like change of hæmoglobin during life is met with in any other disease (with the exception perhaps of Melanosarcoma), and its presence is therefore a sure evidence of naturally or artificially produced malaria.

Once satisfied of the identity of maladies artificially produced in animals by the injection of a crude material with those resulting from spontaneous malarious infection in man, it becomes

necessary to separate from this material the true excitor of disease. Assuming that this infection, like some others of which the etiology is now well known, may be due to animal parasites, its isolation becomes possible. In this material it is presumable that, besides the true excitors of the disease, there are other substances which do not contribute to this result. There may be living organisms or inorganic matter.

We are not concerned with the latter, whose development should encounter more difficulty as conditions are supplied favouring the growth of the former. We know the three conditions (Chapter I.) experience has shown to be indispensable to malaria development. We reproduced these conditions in the following way. In a large well-ventilated air bath were placed on wooden shelves, above a layer of sand heated by gas, some large flat capsules of porcelain. Some of these were filled to the height of 5 cm. with earth kept constantly wet. Others contained a layer of water, renewed as it evaporated, and within which were placed some small tin boxes full of earth. The sides of these were perforated a little way from the bottom, so as to allow the water to penetrate and keep constantly moist the lower strata of the earth. Thermometers were placed so as to show the temperature of the air and earth, and during the entire day a temperature of 30°—35° C. was kept up. In the evening the gas was extinguished, and the air bath and earth in the boxes remained at the same temperature as the air of the laboratory.

In this way we reproduced, in these *artificial* marshes, similar to those of the Campagna, all the conditions of temperature, moisture, and access of air which are found in malarious lands at the time of their greatest activity.

The most notable result was that almost immediately a large number of the organisms in the earth and mud died. The development of diatoms and desmideæ and also of hypomycetæ was suspended. Moulds ceased to form on the surface of the earth and vases, the phenomena of putrefaction were arrested in the marsh mud, whilst they attained a high degree when this was kept under a bell-glass. The elimination of a great part of the organisms in the crude material rendered easy the search for those which are concerned in causing malaria. In this we employed the method devised by one of us (Klebs)—called by him "fractional cultivation," afterwards adopted by Pasteur, and by

means of which he has procured the isolation of various pathogenetic organisms.

When from a liquid containing a not too great variety of organisms one takes a single drop and places it in a cultivation fluid, if this is fit to favour the development of such organisms, these develop in greater number, which are most numerous in the original drop. Ordinarily this preponderance is found in those organisms to which is due the morbigenous energy of the original fluid. If not, the basis of culture and atmospheric conditions are so altered as to result in killing the pathologically inactive organisms, or at least to oppose such obstacles to their development as allow the pathogenetic ones to gain the supremacy. If this happens in one cultivation only, it becomes easy, by repeating the operation, to separate the sparsely developed organisms from the pathogenetic ones, which are always developed more abundantly, and at last obtain a cultivation of these to the exclusion of all others.

If the experiments made with the pure culture show that it excites the same morbid processes as the crude material, it then remains to ascertain if these are due to the liquid basis of cultivation or to the organisms which it contains—probably the latter, as the former is undergoing a geometrically progressive dilution.

To obtain direct proof of the exclusive pathogenetic efficacy of the organisms cultivated, it is necessary to ascertain, by direct experiment, the impotency of the liquid part of the final cultivation.

This is done by filtration through cylinders of potter's clay or filters of plaster of Paris by means of the air-pump (Klebs, Zahn, Pasteur), or even by passing through good filtering paper. The use of this last method is certainly more simple and convenient, but insufficient when one has to do with very minute organisms, as those of septicæmia, diphtheria, rheumatism, and the like; but in the case of malaria we have been able to obtain sometimes by its means a progressive diminution of the efficacy of the filtered liquid. *Since all the fluid parts traverse without obstacle the pores of the filter, one obtains even in this way the proof that the solid particles, retained wholly or for the most part on the filter, are the holders of the pathogenic activity displayed by the cultivation, taken as a whole.*

CHAPTER III.

RESEARCHES.

For the sake of brevity I have introduced the following contractions into the chapter, more particularly in recording the experiments :—

temp.... temperature cent.	L. ..... length.	W. ..... weight.
max. ... maximum.	B. ..... breadth.	I. S..... index of spleen.
min. ... minimum.	T. ..... thickness.	F. A. ... febrile *accès*.

Our researches, being occupied with the solution of the general question, were also directed to the special one of malaria in the Roman Campagna, and it became necessary to select a locality in which, beyond doubt, the gravest forms of the malady are seen in the hot season. The Pontine marshes offered the most suitable conditions, especially as we were able to avail ourselves of the liberal help of the Prince of Teano (Onorato Caetani). Indeed, Cisterna, the central point of the property of the Caetani family, enabled us to extend our observations, on the one side to Ninfa, at the foot of Monte Lepini, and on the other as far as the coast of the Tyrrhene Sea, in the district of the lakes of Fogliano, dei Monaci, and Caprolace.

Although malarious fevers had not yet appeared in these districts at the time of our visit, we determined to examine the air of the same. For this purpose we provided ourselves with a ventilator devised by one of us (Klebs) and made by Herr Rothe, Mechanician to the Physical Institute, Prague.

It consisted of a brass box, elliptical on section, in the centre of which revolved an axle, which sustained four metallic wings, fitted to the cavity of the box and slightly curved.

The aperture for entrance of air is at the side, circular, diameter 2·5 cc. In order to take air from any given point, even at a distance, one can elongate the short metallic tube attached to this aperture, by affixing slender tubes of gutta-percha, united together by caoutchouc tubes. The air issues from the box by means of an aperture of the diameter of a centimetre, to which is fitted a metallic tube projecting beyond the apparatus, and to which can be applied means for collecting the air, either tubes containing liquids or glass slides smeared with gelatine or gly-

cerine to fix the solid particles which impinge upon them. The interior and the fans are kept perfectly clean, because the box is formed of two symmetrical halves united by means of screws. The rotation of the ventilator is secured by clockwork set in motion by two bilateral handles. By its agency one can aspirate 300 litres of air in 16 or 17 minutes, by 50,000 revolutions of the axle, recorded by a register.

We believe this instrument to be the most efficient, superior to the apparatus used by Lewis and Cunningham and to the aspirator of Pouchet. Direct microscopic examination of the air of towns did not yield much result (although we did not neglect to make such in Rome), because of the smallness of the micrococci and their mixture with so many other objects. We attach much greater importance to the "cultivation" of such material, because by its means we obtained some of our most certain results, which prove that "*in malarious districts the poison is raised above the level of the ground, even before the time when the infection becomes manifested in man.*"

Previous to our excursions into the Pontine marshes we collected in Rome four samples of air; and April 9th, one at Ninfa (No. 5); April 10th, one at Tre Ponti, on the Appian Way (No. 6); and on 11th five at the coast lakes (Nos. 7—11). For each sample were employed 300 litres of air from near the ground, in Ninfa from land covered with vegetation, near a ruined church; at Tre Ponti from marshy land; No. 7 from the lake of Fogliano, near to a dune, in a spot exhaling a fœtid odour. The temp. of the water of the lake was 15° at 9.15 A.M.; that of the air, 15°·75. At noon, after rain, the temp. of the water was in the *Fossa papale*, which unites the lakes dei Monaci and Caprolace, 16°·5 and 16°·17; that of the air, 18°·2. Samples Nos. 8 and 9 were taken on the lake of Caprolace between 1 and 2 P.M.; Nos. 10 and 11 on the east bank of the same lake between 2 and 3 P.M. At 4 P.M. the temp. of the water of the *Fossa papale* was 17°; of the air, 17°·6. At 5 P.M., lake of Monaci, temp. of water, 16°; air, 16°·75. At 5.30 P.M., lake of Fogliano, temp. of water, 16°·5; air, 15°·5.

There were also placed on the waters of the lakes pieces of perforated cork, glass slides smeared with gelatine or glycerine being placed on the perforations, face downwards, and covered with little roofs of wax-cloth to protect them from the rain.

The examination of No. 9, made at the summer-house of Fogliano, showed some short rods of the length of 2·25—6·75 m. and breadth of 0·225—0·45 m.; one of the length of 11·25 m., and a piece of vegetable epidermis and a cotton fibre.

In No. 11, besides mineral powder and a few vegetable fibres, were found similar rods to those of No. 9, and some long, curved filaments 22·50 micromillimetres in length.

The water taken April 11th in the middle of the lake of Caprolace, and examined three days after, contained a great quantity of motionless bacteria, threads of algæ coloured with chlorophyl, a few infusoria, the following forms of schistomycetes: 1st, delicate filaments, sometimes very long, homogeneous; 2nd, small rounded corpuscles (micrococci ?); 3rd, automatically moving rods of different lengths; 4th, rounded corpuscles arranged in rows; 5th, filaments, partly jointed, containing shining corpuscles. The mud of Caprolace, taken at the same point on the bank as air samples Nos. 10 and 11, contained the same organic forms, a notable quantity of large infusoria, very many diatomaceæ, and some small worms endowed with very active movements, probably larvæ of nematoids.

April 11th, a very small quantity of this mud was introduced by means of a pin into a cultivation tube, filled with very pure fish gelatine, and immediately closed with cotton already kept at a high temp. (Cultivation tube No. 1.)

April 14th, a portion of the Caprolace water was placed in a similar tube and closed by the lamp. (Cultivation tube No. 2.)

Both were placed in a hot-air bath, temp. 30°—34°.

April 15th, a small portion of the contents of cultivation tube No. 1 were placed in a microscopical air chamber. The examination of it showed that the diatoms were all dead; of the nematoids no trace; the filaments of hypomycetes had not undergone further development. Two forms of schistomycetes were seen; some threads, curved, sometimes twisted; others forming loops in which no trace of differentiation of their structure was found, and some rods with a shining granule at each extremity (Table I., fig. 7, *c*); others even smaller contained a third granule in the middle (Table II., fig. 1, *f*). Besides some filaments devoid of nuclei, others exhibited no sign of division (Table II., fig. *a*), whilst in others the protoplasm was in the middle of its length divided into two by a clear space, in which the presence

of a membrane might be discerned (Table II., fig. 1, *b*). Finally, some long and tortuous filaments were like those of fig. 7, which contained a notable quantity of brilliant granules (Table II., fig. 1, *d*). In these last an extraordinarily rapid development was observed, for whilst fig. *d* represented exactly such a filament as seen at midday (April 15), the same filament had at 2 P.M. assumed the appearance of *d'*; that is to say it had increased to almost double the length, had become larger, and contained a quantity of shining corpuscles, which, especially at the fine extremity, had accumulated so as to give to the protoplasm a much more granular appearance than appears in the figure. Two principal forms, therefore, prevail—homogeneous filaments with commencing scission, and others producing spores, in some of which the protoplasm had become granular. It was only by continued observations of the preparation that it was possible to decide that the two forms were connected. A third form (Table II., fig. 1, *e*) consisted of fusiform cells containing very large protoplasmic masses, of which examples are seen in this preparation, belonging to another organic series, and disappearing as the others developed.

The same cultivation examined April 16th, after having been constantly maintained at a temp. 30°—34°, showed a large quantity of very long filaments with many granules, and others with homogeneous protoplasm sometimes arranged parallel to one another, and in some of which were seen manifold transverse divisions (Table II., fig. 3). April 17th, 9 A.M., were found, in addition, very numerous tortuous filaments, especially at the edge of the air channel, the short rods containing two or three nuclei (fig. 7, *c*, and fig. 1, *f*), which the day previous had been observed at points accurately noted, were no longer visible. Instead, the forms were found which are depicted Table II., fig. 2, as shown by the 1-12th inch objective of Zeiss (oil immersion). The smaller figure represents these same shown with eyepiece No. O of Zeiss, and the other two as seen with eyepiece No. IV. They were jointed filaments, each joint of which was limited by a membrane even at the points of division. The smaller of these had a homogeneous protoplasm; the larger contained a granule, very large, oval, shining, and attached to the wall about the middle; or two granules, smaller, and rounded at the ends; or a median and two terminal granules. Some observations have

l us to think it likely that at the place of occurrence of the edian granule an ulterior division of joints may take place, but e have not been able to watch the process, which probably is ery rapid. The same day at 2 P.M. the articulated filaments rith homogeneous protoplasm (fig. 3) were studied with 1-12th nch Zeiss and No. II. eyepiece. The joints were separated from each other by fine interstices, in which could be seen traces of a dividing membrane, rarely clear lines were distinguished between the two extremities of the joint. The joints were disposed in linear series or were dichotomous. We do not know, however, if this dichotomy is the result of dichotomous division of a joint or of lateral deviation of new terminal joints. The latter is much more probable, as we have never been able to see anywhere the beginning of longitudinal division of the protoplasm.

Sometimes the terminal joints are found in a direction perpendicular to that of the preceding, so that one is led to think that they have been detached, and that the position assumed by them is due to resistance accidentally encountered in the fluid in which they are immersed, as well as to the activity of growth of the joints which had pushed them forward.

At this period of evolution all automatic movement of protoplasm is wanting.

April 26th—*i.e.*, after twelve days of cultivation—at a temp. of 30°—34°, were seen along the whole border of the preparation these filaments, in which no further division had been produced.

They were disposed in groups which, leaving the edge of the air chamber, extended in the form of a fan towards the centre of the preparation; one of these, weakly magnified with objective E of Zeiss and eyepiece No. II., is shown in fig. 6, Table II. Although the joints are feebly connected together, the filaments maintain their continuity, run at first parallel, then diverge, and even cross.

The smaller joints have a length of 2·25 m. and breadth of 1·125 m. From these samples one sees how, under the combined influence of the material chosen as the basis of cultivation, of a fixed temperature, and of the action of the atmosphere, many of the organisms contained in the crude material had perished; whilst from the other part had been developed, in great abundance, forms of schistomycetes, belonging to the genus *Bacillus*. The two different species—the one with homogeneous joints, and

the other with joints containing granules or spores—most probably are derived from one another, because sometimes conjoined in the same plant.

This, therefore, would be a *Bacillus*, which might be distinguished from the *B. subtilis* (F. Cohn) of hay infusions, as from the *Bacillus anthracis* (Kach) of carbuncle, and would be described thus:—

"Rods of the length of 5—10 micromillimetres, which, in developing, are converted into tortuous filaments, divided into joints by means of clear spaces in their protoplasm, or, more rarely, by dividing membranes. These filaments, in the surface exposed to the action of air, produce rows of very short joints, and develop in their interior spores before their division into joints, or after this has happened. These spores occupy the middle, or extremities, of the joints, or both at the same time; when the division into joints does not happen they are multiplied by becoming still smaller, and the interior of the filament is filled by a granular mass."

Inasmuch as the same forms are repeatedly produced by like cultivation, practised in fish gelatine, with different kinds of soil, taken from malarious places (whilst other organic forms are not seen except occasionally, or perish, in consequence of the preponderating development of this *Bacillus*), we supposed that perhaps this plant might be the carrier of malaria, which led us to proceed by experiments on animals to test the value of this conjecture.

Our experiments were performed on rabbits of good breed, for the most part very robust, in which autopsies never disclosed any change due to antecedent disease. They were kept in spacious and well-ventilated stalls of wood, placed in a part of the laboratory near our work room, the large windows of which were always kept open. The floor of each was formed of a network of iron wire, and under this a zinc funnel received and conveyed the urine to a vessel outside the stall. The stalls and floor of the room were cleansed most scrupulously. The animals were fed with cabbage leaves, and on their entrance into the laboratory were marked with Roman numerals, which, to avoid confusion, were written with aniline colours on the skin of the back, denuded of fur.

The same number has been used to distinguish the temp.

curve (Tables III., IV., V.) and the "nature print" of the spleen (Table I.) of each animal, to facilitate comparison.

Since, for the most part, parallel researches were made with various substances, we may divide the former into groups.

Group I. *Normal rabbits.*—In order to determine the normal size of the spleen, two very fine rabbits were selected, strong and healthy (XVII. and XVIII.), and killed as soon as they were brought to the laboratory. Death was effected by means of a tight noose round the neck and strong simultaneous traction on the hind legs. This mode was adopted with all our animals except Nos. I. and II., which were killed by bleeding. It procured an immediate death without convulsions, so as to avoid disturbance of the circulation capable of altering the volume of the spleen.

In order to avoid the action of extraneous fluid on the spleen, we abstained from determining the volume of this organ.

Even an exact determination of its weight was difficult, owing to evaporation in an organ which, though small in rabbits, has a relatively very large surface.

We therefore, instead of determining the volume and weight, sought to obtain from the nature-print of the organ, immediately after death, some figures in relation to the weight of the animal's body. We did this by multiplying together the three measurements (L., B., and T.) in millimetres of the print and calculating the value of this parallelopiped, in relation to a chilogramme of the body weight. To this relative value we gave the name *Index of the Spleen*, indicated by the letters I. S.

In these two rabbits all the organs were healthy, and the spleens are represented Table I., Nos. XVII. and XVIII. We obtained the following values:—

Table I.—*Spleen of Normal Rabbits.*

Number.	Weight of Body in Grammes.	Diameters of Spleen in Millimetres.			Product of Three Dimensions.	I. S.
		Length.	Breadth.	Thickness.		
XVII....	1,755	38·8	8·2	3·6	1,145	—
XVIII...	1,591	38·7	9·4	3·7	1,079	—
Mean ...	1,673	38·75	8·8	3·65	1,112	664

Immediately before death the temperature of XVII. was 39°, and that of XVIII. 38°·6. This temperature, however, is not considered normal, because we often found that the animals on entering the laboratory had a subnormal temperature, and only recovered the normal after 24 hours. The following table shows the means obtained by 7—9 daily measurements, made for nine days on six rabbits.

(Before calculating the means, it was necessary to make the correction of the thermometer, which, as already stated, was 0°·1 C. below the normal.)

TABLE II.—*Calculation of Mean Rectal Temperature of Rabbits.*

Number.	Date of Observation.	Daily Mean.	No. of Daily Measurements.	Place of Observation.
V.	April 30	39°·556 C.	9	Rome
„	May 1	39·516	„	„
XII.	„ 9	39·457	7	„
„	„ 10	39·483	9	„
„	„ 11	39·471	„	„
XV.	„ 17	39·162	8	„
XVI.	„ „	39·768	„	„
XIX.	June 8	39·368	„	Prague
XX.	„ „	39·475	„	„
General mean ..... = 39°·4745, from 75 measurements.				

We believe we are near the truth in estimating the mean temp. of the rectum in rabbits at 39°·5, and therefore in our temp. curves (Tables III., IV., and V.) we have at this level drawn a well-marked line representing this normal.

In the analysis of pathological cases, we think it convenient to form three groups (II., III., and IV.), according to the source of infecting material used—Pontine marshes, Janiculan, Valchetta in the Roman Campagna. In a fifth group, researches made at Prague in the same way as at Rome; and in the sixth group, cases of septic infection accidentally produced in some animals not used in our experiments, but offering excellent means of comparison with those of malarious infection, artificially induced at the same time and place.

GROUP II. ***Researches with infecting material collected in the Pontine Marshes.***—These, made on Nos. I., II., III., IV., V., served to test the material collected at the lake of Caprolace and in the air of Ninfa and Fogliano, without preparation or after-cultivation (microscopic analysis already given).

A. ***Parallel researches with Caprolace mud.***—No. I. was injected April 16th, 10 A.M., with 1·6 cc. of water which had rested three days on Caprolace mud, and immediately afterwards No. II. was injected with 0·6 cc. of fluid from cultivation tube No. I., in which the same mud had been cultivated in fish gelatine since April 11th, and on the same day (April 16th) showed the bacilli provided with spores in fig. 7, *c*, and fig. 1, *f*, Table II.

TABLE III.—*Temperature and Weights of Nos.* I. *and* II.

Day.	Hour.	Rectal Temp.		Weight of Body in Grammes.		Day.	Hour.	Rectal Temp.		Weight of Body in Grammes.	
		I.	II.	I.	II.			I.	II.	I.	II.
Apr. 15	—	—	*	1,560	1,801	Apr. 20	11.40 a.m.	40·8	39·8	—	—
„ 16	10 a.m.	39·2	39·0	—	—	„ „	2.30 p.m	40·5	39·4	—	—
„ „	2.30 p.m.	40·15	39 9	—	—	„ „	3 „	40·5	39·4	—	—
„ „	8 „	39·85	40·2	—	—	„ „	6.40 „	40·7	39·8	—	—
„ 17	9.30 a.m.	39·5	39·7	1,443	1,684	„ „	10 „	40·3	39·6	—	—
„ „	2 p.m.	38·4	38·9	—	—	„ 21	6 a.m.	40·8	39·7	—	—
„ 18	9.40 a.m.	39·4	39·45	1,445	1,708	„ „	8 „	40·7	39·7	†	—
„ „	3 p.m.	38·4	39·7	1,461	1,780	„ „	9.15 „	40·9	—	1,837	—
„ „	5 „	39·75	39·7	—	—	„ „	11.30 „	—	39·65	—	—
„ „	8.30 „	39·7	39·5	—	—	„ „	7 p.m	—	39·8	—	—
„ 19	9.15 a.m.	40·0	39·6	1,408	1,783	„ „	10 45 „	—	39·8	—	—
„ „	11 „	40·2	39·6	—	—	„ 22	6 a.m.	—	39·8	—	—
„ „	2 p.m.	40 6	40·1	—	—	„ „	12.45 p.m	—	39·4	—	—
„ „	3 „	40·65	40·05	—	—	„ „	1 „	—	39·9	—	—
„ „	4 „	40·85	40·2	—	—	„ „	3 „	—	39·9	—	—
„ „	5 „	40·8	40·2	—	—	„ 23	12 a.m.	—	39·5	—	—
„ „	6 „	40·5	40 2	—	—	„ „	6 p.m.	—	39·5	—	—
„ „	8 „	40·6	40·6	—	—	„ 24	6 a.m	—	39·2	—	—
„ „	11 „	40·5	40 3	—	—	„ „	12 „	—	39·6	—	—
„ 20	6 a.m.	40·7	39·6	—	—	„ „	6 p.m.	—	39·8	—	—
„ „	8.10 „	40·6	39·7	—	—	„ 25	7 a.m.	—	39·5	—	—
„ „	8.10 „	40·65	39 8	—	—						

* Subcutaneous injection of above mentioned material into both rabbits.
† No. I killed by bleeding.

Add correction 0°·1 in each table.

Autopsy of No. I., immediately after death. At injection site large callosity (4 cm. × 3·5 cm.) of whitish and apparently fibrous connective tissue, containing blood vessels fi

hard, dark red thrombi, subcutaneous tissue slightly œdematous. The œdema fluid, collected immediately by means of capillary tubes, contains a great quantity of automatically moving corpuscles, of oval or rounded form, shining, some showing on opposite sides small blunt prolongations. In addition, immovable or feebly moving filaments, 5·9001 m. max. L.; 0·7143 m. B. Mesenteric lymphatic glands swollen, and contain large quantity of opaline fluid. Spleen, enlarged: 55 mm. L., 9 B., and 4 T. Examination of its fresh tissue shows a great quantity of dark brown pigment in irregular masses; adding aqueous humour taken from eye of the same rabbit, and perfectly normal, a great number of actively moving rounded corpuscles were seen. No change in other organs.

To determine well the nature of the rounded bodies in the splenic pulp and lymphatic fluid, two air cells were employed (Nos. 7 and 8). In the first was placed serum of the lymph, in the second a little splenic pulp diluted with aqueous humour. Both were maintained at 30°—35° (the glasses having previously been heated to 120° to kill any organisms on them). After 24 hours No. 7 contained motionless filaments with brilliant granules (spores) and self-moving rods, sometimes united in couples, besides free oval bodies, like those in the filaments (Table II., fig. 4). In No. 8 were formed, besides many free spores, some filaments with homogeneous protoplasm.

These, especially the smaller ones, could only be seen with 1-12 or 1-18 inch objective of Zeiss and Abbé illumination. (Afterwards they were seen well with weaker objectives.)

In both rabbits a fever of intermittent character followed the injection of the above substances (Table III., curves I. and II.). After injection an immediate rise to 40° took place; next day, a fall below the normal; 3rd day, a slight rise; 4th, a new F. A. (febrile *accès*) to 40·85 in No. I., and to 40·6 in No. II. After the 5th day the course was different in the two. No. I. maintained a high temp. for 48 hours with slight oscillations, whilst No. II. showed slight rises on the 5th, 6th, and 7th days, with daily remissions; on the 8th, a normal temp.; on the 9th, a subnormal in the morning and a slight rise in the afternoon. In the 10th, used for another experiment.

We see, therefore, the fever in No. I. continue after the second F. A., and in No. II. an almost normal condition after the second

F. A.—a difference dependent upon the quantity of infecting material used.

As to the *post-mortem* appearances met with in No. I.—killed during the F. A.—we note, 1st, the absence of suppuration at injection site; 2nd, the increase, in all dimensions, of the spleen, especially its length, I. S. 1,298, *i.e.*, almost double the normal (664); 3rd, the presence of the organisms of the injected liquid, in the injection site, spleen, and lymph. Neither the course nor *post-mortem* conditions correspond to those of putrid and septic fevers. Also the increase of weight between first and second F. A.

B. *Parallel researches with Caprolace mud and with material collected in the air of Ninfa and Fogliano*, to ascertain if the infecting agent is, even before the fevers appear, diffused in the lower strata of the air of such places. It is not unlikely that the greater activity displayed by the sample from Fogliano, where the odour of putrescence was strong, may point, in accordance with the ideas of the inhabitants, to a greater infective power.

April 17th were begun some cultivations with the samples of air Nos. 5 and 7, collected at Ninfa and Lake Fogliano. The isinglass with which the slides had been smeared was dried: a portion placed with albumen in two air cells (microscopic), a second in two tubes of very pure fish jelly, and a third in urine. The latter had long been boiled in a small retort, which was afterwards closed with cotton, and remained perfectly clear during 24 hours. The cultivation with albumen gave no result. In the tubes of fish gelatine the development of bacteria took place, and was reserved for other researches. The urine cultivation was used at once. It was pale yellow, clear, and acid; contained long motionless filaments, partly jointed, and in some of the joints spores were seen.

April 25th, 1·6 cc. of this urine were injected under the skin of No. II., and simultaneously No. III. (not used before in any experiment) was injected with 3 cc. of water, which had long stood on Caprolace mud, containing some oval corpuscles and slender, twisted filaments.* There were also injected into another rabbit, No. IV., 1·6 cc. of a cultivation tube in which

* The microscopic examinations were always made by both observers, and separately recorded by each.

had been placed, April 23rd, a very small quantity of (mud with fish gelatine. In this liquid were seen on shining granules.

The results are seen in the following table :—

TABLE IV.—*Temperature and Weights of Nos.* II., III., *a*

Day.	Hour.	Temperature.			Weight of Body.			Observation
		II.	III.	IV.	II.	III.	IV.	
Apr. 25	7 a.m.	39·5	—	—				
" "	8 "	—	38·9	38·5				
" "	9 "	—	—	—	1,686	1,546	1,824	Injection.
" "	10 "	39·4	39·3	39·1				
" "	12 "	39·6	39·6	39·2				
" "	2 p.m.	39·6	39·2	38·8				
" "	4 "	39·7	39·3	38·7				
" "	6 "	39·9	39·2	39·0				
" "	8 "	39·8	39·2	39·2				
" "	10 "	39·8	39·2	39·2				
" 26	6 a.m.	39·4	38·9	39·1				
" "	8 "	39·6	39·4*a*	38·75	*b* —	—	—	*a*. During the mo
" "	10.15 "	39·4	39·4	39·8				the animal, 39·6.
" "	12 "	39·35	39·5	38·5				*b*. At 8.30 a.m. N
" "	2 p.m.	39·5	39·0	38·6				jected with 3·4
" "	4 "	39·6	39·3	39·0				same cultivation.
" "	6 "	39·7	39·5	39·5	—	—	—	No. IV. had six yo
" "	8 "	39·5	39·4	39·4				
" "	10 "	39·6	39·4	39·4				
" 27	6 a.m.	39·3	39·2	39·5				
" "	8 "	39·6	39·3	39·45	1,717	1,871	1,532	The weight of the was 262; that of No. IV., 1,532: t
" "	10 "	39·4*c*	39·2*d*	39·6	—	—	—	*c*. Injection of 3 c
" "	12 "	39·5	40·5	39·65				vation in urine o
" "	2 p.m.	39·7	40·1	40·05				air of Ninfa and
" "	4 "	39·7	40·2	39·9				*d*. 3 cc. of water fr
" "	6 "	39·8	40·2	39·6				Caprolace injecte
" "	8 "	39·8	39·9	39·8				
" "	10 "	39·8	39·9	39·9	1,883	1,615	1,530	
" 28	6 a.m.	39·65	39·3	39·7				
" "	8 "	39·7	39·4	39·6				
" "	10 "	39·3	39·25	39·5				
" "	12 "	39·4	39·3	39·4				
" "	2 p.m.	39·5	39·45	39·5				
" "	4 "	39·75	39·4	39·45				
" "	6 "	39·6	39·4	39·7				
" "	8 "	39·6	39·5	39·65				
" "	10 "	39·65	39·25	39·8				
" 29	6 a.m.	39·4	39·3	40·05				
" "	8 "	39·6	39·0	41·00				
" "	10 "	39·5	39·2	39·9				
" "	12 "	39·6	39·2	40·2				
" "	2 p.m.	39·4	39·3	40·05				
" "	6 "	39·6	39·2	40·05				
" "	8 "	39·95	39·55	40·3				
" "	10 "	39·8	39·45	41·05				
" 30	6 a.m.	41·0	39·1	41·0				
" "	8 "	39·95	39·2	39·8				
" "	10 "	40·2	39·0	40·2	1,749	1,668	1,632	
" "	12 "	40·1	39·2	40·4				

Temperatures and Weights of Nos. II., III., *and* IV.—*Continued.*

Day.	Hour.	Temperature.			Weight of Body.			Observations.
		II.	III.	IV.	II.	III.	IV.	
Apr. 30	2 p.m.	39·8	39·2	40 2				
" "	4 "	39·5	39·2	40·2				
" "	6 "	39·55	39·3	40·15				
" "	8 "	39·4	39·2	39·9				
" "	10 "	39·5	39·2	40·1				
May 1	6 a.m.	39·5	39·2	40·1				
" "	8 "	39·35	39·4	39·9				
" "	10 "	39·1	39·5	39·85				
" "	12 "	39·25	39·3	39·95				
" "	2 p.m.	39·45	39·2	40·05				
" "	4 "	39·4	39·3	39·9				
" "	6 "	39·4	39·1	40·0				
" "	8 "	39·5	39·4	40·1				
" "	10 "	39·6	39·3	40·0				
" 2	6 a.m.	39·3	39·4	40·1				
" "	8 "	39·4	39·1	39·85				
" "	10 "	39·2	39·3	39·9				
" "	12 "	39·5	39·2	39·6				
" "	2 p.m.	39·5	39·2	39·7	1,745	1,612	1,490	
" "	4 "	39·4	39·3*e*	39·9	—	—	—	*e*. At 3.30 p.m. No. III. injected with 16 cc. of filtered fluid of cultivation of Ninfa and Fogliano air, in urine. See parallel experiment following.
" "	6 "	39·7	—	40·5				
" "	8 "	39·8	—	39·9				
" "	10 "	40·0	—	39·95				
" 3	6 a.m.	39·5	—	*f*	—	—	—	*f*. Thermometer broken. New one also, 0·1 below normal.
" "	12 "	39·2	—	—				
" "	2 p.m.	39·85	—	40 0				
" "	4 "	39·7	—	40·0				
" "	6 "	40 0	—	40·1				
" "	8 "	40·1	—	39·8				
" "	10 "	40·0	—	39·9				
" 4	6 a.m.	39·9	—	40·1				
" "	8 "	39·5	—	39·9				
" "	12 "	39·6	—	40·0				
" "	2 p.m.	40·0	—	40·1				
" "	4 "	40·1	—	40 0				
" "	6 "	39·8	—	40 05				
" "	8 "	39·85	—	40·0				
" "	10 "	39·7	—	40·0				
" 5	6 a.m.	39·5	—	40·0				
" "	8 "	39·7	—	39·8				
" "	12 "	39·7	—	39·2	1,910	—	1,529	
" "	2 p.m.	39·8	—	36·6	—	—	—	At 2.30 No. IV. killed.
" "	4 "	39·8	—	—				
" "	6 "	40·0	—	—				
" "	8 "	40·1	—	—				
" "	10 "	40·0	—	—				

Temp. table of No. III. will be continued below.

No. II. killed May 6th by bleeding. At 6 A.M. of this day its rectal temperature was 39°·9; at 8 A.M., 39°·8; at 10 A.M. 39°·4. Weight, 1,602 grammes.

Autopsy.—Well nourished (on the 11th day of observation it weighed 224 gr., and on the day of death 116 gr., more than

when it came to the laboratory). Spleen much enlarged (Table I., fig. 2.); L. 52·6 mm.; B. 11·5 mm.; T. 5·8 mm.; I. S. (compared with maximum weight on 11th day) 1,832, i.e., almost treble the normal—firm, not rich in blood, of clear red colour, and its capsule wrinkled. Intestinal glands not swollen, but mesenteric lymphatics much enlarged, forming at the root of mesentery a mass—3 cm. × 1·8 cm.—firm, whitish, and containing much lymph. Liver rich in blood. Kidneys less so. Slight pulmonary œdema, with subpleural ecchymoses. At one injection site a small capsuled abscess.

Temp. curve (Table III., curve II.) very interesting. First two days after first injection temp. oscillations slight. First 48 hours after second injection notable perturbations observed. Temp. commenced to rise rapidly 51 hours after second injection, arriving in 16 hours at 41°. The F. A. had a duration of 24 hours.

In 36 hours following, minima of 39°·1—39°·2, and maxima almost normal. Then a series of 4 F. A. (*f*, *g*, *h*, *i*), each lasting about 24 hours, with maxima of 40°, 40°·1, 40°·1, 40°·1, and maxima of 39°·2, 39°·5, 39°·5.

The quartan type of fever after F. A.—f. was transformed into a quotidian type.

The *post-mortem* appearances exclude septic complication.

Melanæmic pigment was found in the spleen. In the lymph were found many brilliant actively moving oval bodies, 0·0005 mm. long.

It results, therefore, that the air examined contained corpuscles capable of development, which, after multiplication in urine, were rendered capable of producing attacks of intermittent fever in the animals injected with them.

To get this result it was necessary to use a considerable quantity of cultivation liquid, and it occurred after a period of latency of 48 hours. This is explained by the large quantity of fluid (400 cc.) in which was diffused the material in cultivation.

It remained to be seen if the febrigenous action was due to the solid particles in this liquid, or to some other substance in it. And to this end we made the following experiment:—

No. III., already injected twice with water from Caprolace mud (1·6 cc. April 25th, 3·2 cc. April 27th), showed two slight rises after the first injection (Table III., curve III., *a*, *b*), the

maxima being 24 hours apart, and the difference of max. and min. only 0°·7.

All this curve is subnormal. After the second min. the temp. ascended to the mean. (Such oscillations are very often seen in rabbits placed under new conditions of life, food, &c., and have nothing to do with intermittent fever. Of this in the present case we had a positive proof.) When the temp. had become normal, a double dose of the same fluid was injected, and the temp. at once rose to 40°·2, then fell, so that for five days the curve was subnormal, only once passing the normal by 0°·1. Therefore the two injections were powerless to produce an intermittent fever, or in other words, *water which had long been in contact with mud rich in malaria did not seem apt to transmit this poison.*

The negative result in this case was not due to immunity of the animal, because a later experiment on it showed that such immunity did not exist. This result has an important bearing on the fact, that the natural development of malaria is known to be wanting when a sufficient layer of water covers and separates the soil from the atmosphere. The Caprolace water was in our researches shown to be devoid of those organisms which may be developed in such quantities from cultivations made with the mud itself, which produced such positive results in No. II.

This water was rich in self-moving schistomycetes, but in no cultivation with fish gelatine, albumen, urine, or even left to itself in flasks closed with cotton, were bacilli ever seen to develop containing nuclei. The forms were always such as one of us (Klebs) has described as *monadine*, which goes to prove that the bacillus described by us is eminently *ærobic*, which only grows in contact with the air, and accords with the conditions of malaria development set forth in Chapter I., and with our researches, in which the plant always grew on the surface of the fluid.

No. IV., the third of this series, which was injected with 1·6 cc. of a cultivation of the bacillus in fish gelatine, was in conformation and origin like No. III. Both were strong albinoes, probably of one litter, and were kept in the same stall.

No. IV. had also at first a subnormal temp. In the first days after injection it showed slight temp. oscillations, but always subnormal. Towards the middle of the third day, temp. rose

above the mean, and at 2 P.M. surpassed 40°, then slowly fell to 39°·4 on the day following. On the fifth there was a strong F. A. (max. 41°), *so that, as happens in the tertian type, the two accesses were separated by a day of complete apyrexia.* But the same evening there was a stronger and more lasting rise of eight hours' duration, temp. 41°·05. For five days the temp. remained high (40°) with slight exacerbations and remissions. *So that after the strong accès of eight hours the fever became subcontinued.*

On the sixth day the fever declined (temp. 39°·2). The animal was killed. Before entering on the details of the autopsy we think it would be useful to note a fact which seems important. Our expectations of positive results in Nos. III. and IV. were at first illusory, and the sudden strong *accès* of the 29th took us by surprise. It is noteworthy that on this day heavy falls of rain occurred, and a great fall of temp., and that in No. II. on which three days before had been practised the last injection there took place a notable rise immediately succeeding the strong *accès*, *e* (Table III., curves I., II.) On the contrary Nos. V. and VI., not yet used for experiments, and No. III. which had been injected with an inactive material, showed *conspicuous fall* of temp.

It seems that the infected animals resisted this atmospheric change differently to the non-infected ones.

The following data, furnished by the Director of the Observatory of the Roman College, show what these were:—

Day.	Barometer Reduced to Sea Level.	Temp.		Humidity per cent.	Rain in Milli-metres.	Wind.
		Max.	Min.			
April 25	756·6	19·7	9·1	66	3·3	N., S.W.
„ 26	759·5	19·1	7·0	68	drops	N., S.W.
„ 27	758·7	19·2	12·1	69	2·7	S.W., S.E., N.W.
„ 28	754·5	16·7	9·7	66	11·3	E., S.E., S.W.
„ 29	754·0	13·2	9 4	88	66·0	N., N.E.
„ 30	756·8	15·0	8·3	79	8·0	N., N.W.
May 1	759·0	17·9	8 3	68	0	N., S.W.
„ 2	758·8	15·3	7·5	78	6·0	S.E.
„ 3	755·3	14·5	8·2	80	30·2	S.E.
„ 4	757·8	16·5	8·0	71	10·0	N., S.W.
„ 5	760·9	18·0	8·0	83	22·4	N., S.W., N.

We see corresponding to the 29th, lower temp.; diminished atmospheric pressure; greater humidity; heavy rain. On the

30th the atmospheric pressure increases, but the min. temp. is still lower.

It is therefore probable that cooling of the air and increase of its humidity had influenced the production of the strong febrile accesses in the infected, and had determined a fall of temp. in the non-infected animals.

Autopsy, No. IV.—Well nourished; had gained W. 63 gr. since April 26th. Spleen greatly enlarged (Table I., fig. 4); L. 67·3 mm.; B. 13 mm.; T. 4·3 mm.; I. S. 2,460, *i.e.*, four times the normal, contracted, capsule wrinkled, and poor in blood. Liver and kidneys congested, but normal. Mesenteric glands enlarged, whitish, rich in lymph. Patches of Peyer slightly elevated, and greyish white. Intestinal mucous membrane slightly reddened. Uterus large, placental insertion faint, mucous membrane smooth, reddish. Lungs large, subpleural ecchymoses. Heart contracted. Abdominal veins contain much fluid blood. In the lymph many oval shining corpuscles with active movement; a few also in the spleen. Cultivations were made with blood collected in capillary tubes. In one bacillus development took place. In the spleen were many large cells containing fragments of red globules and many shining granules; much brown and a considerable quantity of black pigment in this spleen, which pigment was stained blue by ferrocyanide of potassium and hydrochloric acid.

C. *Parallel experiments on the efficacy of fluid obtained by cultivation in urine of samples of air collected in Ninfa and Fogliano.*—These had for their object to discover if any difference existed between the action of the cultivation fluid before and after filtration.

The cultivation fluid, by means of which the malarious infection had already been produced in No. II., was filtered through a cell of plaster of Paris by means of a Bunsen's pump.

Sixteen cc. of filtered fluid were injected, May 2nd, by several punctures under the skin of the back of No. III., which had since April 29th onwards had a normal temperature, and from previous researches might be supposed to have a predisposition to resist malarious infection.

Into No. V., not used in any previous experiment, was injected only 3·2 cc. of the liquid remaining in the filter.

TABLE V.—*Temperatures and Weights of Nos. III. and V.*

Day.	Hour.	Temperatures and Weights.		Difference in Temperature of No. V. from III.	Day.	Hour.	Temperatures and Weights.		Difference in Temperature of No. V. from III.
		III.	V.				III.	V.	
May 2	6 a.m.	39·4	39·7	+ 0·3	May 6	8 p.m.	39·8	40·1	+ 0·3
„ „	8 „	39·1	39·6	+ 0·5	„ „	10 „	39·5	40·8	+ 0·5
„ „	10 „	39·3	39·5	+ 0·2	„ 7	6 a.m.	39·55	39·8	+ 0·25
„ „	12 „	39·2	39·6	+ 0·4	„ „	8 „	39·7	39·9	+ 0·2
„ „	2 p.m.	39·2	39·5	+ 0·3	„ „	10 „	39·5	39·9	+ 0·4
„ „	—	1612gr.	1798gr.	—	„ „	12 noon	39·3	39·8	+ 0·5
„ „	4 „	39·3	39·4	+ 0·1*	„ „	2 p.m.	39·4	40·1	+ 0·7
„ „	6 „	39·6	40·0	+ 0·2	„ „	4 „	39·7	40·1	+ 0·4
„ „	8 „	40·1	40·42	+ 0·32	„ „	6 „	40·0	40·2	+ 0·2
„ „	10 „	40·25	40·2	— 0·05	„ „	8 „	39·7	40·1	+ 0·4
„ „	12 „	40·2	39·9	— 0·03	„ „	10 „	39·8	40·0	+ 0·2
„ 3	12 noon	39·1	40·4	+ 1·3	„ 8	6 a.m.	39·3	40·0	+ 0·7
„ „	2 p.m.	39·5	40·2	+ 0·7	„ „	8 „	39·65	39·9	+ 0·25
„ „	4 „	39·35	40·2	+ 0·85	„ „	10 „	39·3	39·85	+ 0·55
„ „	6 „	39·7	40·3	+ 0·6	„ „	12 „	39·4	39·9	+ 0·5
„ „	8 „	39·8	40·3	+ 0·5	„ „	2 p.m.	39·2	40·0	+ 0·8
„ „	10 „	39·6	40·1	+ 0·5	„ „	4 „	39·5	40·1	+ 0·55
„ 4	6 a.m.	39·5	40·0	+ 0·5	„ „	6 „	39·6	40·3	+ 0·7
„ „	8 „	39·65	39·85	+ 0·2	„ „	8 „	39·5	40·0	+ 0·5
„ „	12 noon	39·7	39·6	— 0·1	„ „	10 „	39·4	39·9	+ 0·5
„ „	2 p.m.	39·8	39·5	— 0·2	„ 9	6 a.m.	39·4	39·8	+ 0·4
„ „	4 „	39·5	40·0	+ 0·5	„ „	8 „	39·2	39·7	+ 0·5
„ „	6 „	39·4	40·0	+ 0·6	„ „	10 „	39·2	39·9	+ 0·7
„ „	8 „	39·6	40·05	+ 0·45	„ „	2 p.m.	39·5	40·0	+ 0·5
„ „	10 „	39·55	39·95	+ 0·4	„ „	4 „	—	40·0	
„ 5	6 a.m.	39·2	39·9	+ 0·7	„ „	6 „	39·7	39·9	+ 0·2
„ „	8 „	40·0	39·85	— 0·15	„ „	8 „	39·6	39·95	+ 0·35
„ „	11 „	1657gr.	1767gr.	—	„ „	10 „	39·65	40·0	+ 0·35
„ „	12 noon	39·35	39·9	+ 0·55	„ 10	6 a.m.	39·3	39·9	+ 0·6
„ „	2 p.m.	39·7	39·8	+ 0·1	„ „	8 „	39·6	39·9	+ 0·3
„ „	4 „	39·6	40·0	+ 0·4	„ „	10 „	39·6	39·85	+ 0·25
„ „	6 „	39·7	40·5	+ 0·8	„ „	12 „	39·5	39·9	+ 0·4
„ „	8 „	39·8	40·4	+ 0·6	„ „	2 p.m.	39·4	40·0	+ 0·6
„ „	10 „	39·7	40·1	+ 0·4	„ „	4 „	39·6	40·05	+ 0·45
„ 6	6 a.m.	39·3	39·6	+ 0·3	„ „	6 „	39·7	40·0	+ 0·3
„ „	8 „	39·7	39·8	+ 0·1	„ „	8 „	39·8	39·9	+ 0·1
„ „	10 „	39·1	39·7	+ 0·6	„ „	10 „	39·6	39·85	+ 0·25
„ „	12 noon	39·3	39·9	+ 0·6	„ 11	6 a.m.	39·5	39·9	+ 0·4
„ „	2 p.m.	39·4	40·0	+ 0·6	„ „	8 „	39·4	39·7	+ 0·3
„ „	4 „	39·6	40·15	+ 0·55	„ „	10 „	1759gr	1807gr.	†
„ „	6 „	39·7	40·1	+ 0·4					

* Injection of both. † Both killed.

Autopsy.—Results identical with the cases explained further back. No suppuration at injection sites, not even No. III., in which there were so many punctures; sup. mesenteric glands enlarged. Both spleens enlarged, but in different proportions. (Table I., figs. 3 and 5.)

	L.	B.	T.	W. of Body.	I. S.
No. III.	51 mm. ...	11·8 ...	4·2 ...	1,757 ...	1,410
„ V.	56 „ ...	11·2 ...	5·6 ...	1,807 ...	1,943

Whilst spleen No. III. contained no pigment except in the form of small granules of a rusty colour, enclosed in a few white cells scattered widely apart, that of No. V. was rich in pigment. The most of this was nickel-coloured, and enclosed in the white cells as granules or in very voluminous masses, or had taken the place of hæmoglobin in the red globules. Some of these had preserved their dimensions, homogeneity, and discoid shape, but the hæmoglobin was replaced by pigment. Besides the nickel-coloured, a certain amount of black pigment was met with in the spleen, chiefly as granules enclosed in white cells. These results and the temp. curves (Table III., curves III. and V.) show that a malarious infection was produced in both, but of less intensity by the filtered than by the unfiltered fluid, although No. III. was weakened by a previous experiment.

The fever type in V. was quotidian, with max. intensity at the 1st, 4th, and 7th F. A., as if it was a combination of a quotidian and a tertian. Without wishing to assign an undue value to the manifold distinctions in the simple and compound forms of intermittent, we think it very probable that the great variety of type depends on corresponding variety in the intensity of the infecting agent, which may have a diagnostic importance. Probably very frequent measurements of the temp. in man would tend to increase the number of recognized forms.

This experiment tells in favour of the conclusion that separation of the solid particles of an infecting fluid robs it of much of its power and generates a mild type of fever. The degree of completeness of the separation is, in our cases, uncertain, but at all events it goes to confirm what was discovered by cultivations, viz., *that the solid particles capable of development are the carriers of the virus;* however, we cannot yet absolutely exclude the possibility that the fluid in which the organisms are suspended, and in which the products of their material change are found, may concur in the morbigenous action they undoubtedly possess. Experiments on Nos. XV. and XVI., and on VIII. and XII., gave an analogous result.

D. *Parallel researches with the bacillus malariæ cultivated in an open and a closed vessel.*

April 23rd.—To two cultivation tubes of fish gelatine was added a very small quantity of Caprolace mud, one sealed by the

lamp, the other plugged with cotton, previously kept at a high temp.; both maintained at 30° to 50°.

May 5th.—A whitish scum appeared on the first tube denser than that on the second. Examined microscopically, motionless rods were seen in the first cultivation, and others which oscillated gently. In the first were brilliant nuclei, which were wanting in the second; in addition many free oval spores were seen. In the second cultivation only rods and motionless filaments with spores. Tubes closed, and, May 9th, contents used for two parallel researches.

May 9th, 10 A.M.—No. IX. injected with 1·04 cc. of open cultivation, and No. X. with 3·2 cc. of closed cultivation.

No. IX. had from the commencement a strong F. A. of 24 hours' duration, with two max. temp. of 40°·3 and 40°·2, and interposed min. of 39°·45 (Table IV., curve IX.). On the 11th, 12th, and 13th the temp. was normal, with rather marked oscillations; 14th appeared a F. A., which lasted 48 hours, and in which three notable rises of temp. were observed with intervening falls, during which the temp. was always above the normal (curve IX., *a*, *b*, *c*). May 16th, 6 A.M., temperature still 40°; at 10 A.M. fell to 39°·2, *i.e.*, sub-normal; 17th, 18th, and 19th, temp. at or below normal; 20th, in the morning aborted [two]; temp. at 6 P.M., 39°·8. Killed.

No. X. Very similar temp. curve (Table IV., c. X.); first F. A. after injection and two maxima, but nearer together. Three days following temp. fell, but always above the normal. 13th, 6 A.M., temp. 40°·05. This second *accès* commenced a day earlier than in No. IX., lasted three days, and showed four chief phases of recrudescence and remission (c. X., *a*, b^2, *c*, *d*). The maxima and minima are a little lower than in No. IX. On five succeeding days temp. above, and then fell to normal.

Although in No. X. the quantity of injected material was greater than in No. IX., the first F. A. was shorter, and the second represented a subcontinuous of less intensity and longer duration. It is probable the infective power of the closed was less than that of the open cultivation, and would have been more marked if the former had not contained a notable quantity of air. In fact, in the cultivations made with absolute exclusion of air, the development of the bacillus was suspended, and they could not be used for experiment.

The following table shows that after the injection and first F. A. they gained weight, and this in No. X. continued up to death:—

	IX.		X.	
May 8.....	1,902 gr.	.....	1,819 gr.	
„ 9.....	1,818 „	.....	1,715 „	Injection.
„ 16.....	1,893 „	.....	1,796 „	After second *accès* of fever.
„ 17.....	1,775 „	.....	1,813 „	
„ 18.....	1,777 „	.....	—	
„ 20.....	—	.....	—	No. IX. aborted (weight of two abortions, 65gr.)
„ 21.....	1,596 „	.....	1,847 „	

Both killed May 21st. No. IX., spleen moderately enlarged, firm and dark-coloured; that of No. X. more voluminous, clearer coloured, and softish. In both slight pulmonary œdema, and in No. X. intra-alveolar extravasations. Size of spleen as follows (Table I., figs. 9 and 10):—

	L.	B.	T.	I. S.
No. IX.	... 46·0 mm.	... 10·8 mm.	... 3·0 mm.	... 984
„ X.	... 60·8 „	... 13·7 „	... 6·1 „	... 2,754

These two experiments prove that bacilli cultivated in fish gelatine produce intermittent fevers, but do not establish a decided difference between those cultivated in open and in closed vessels.

Group III. *Researches with samples of soil of the Janiculan.*—Dr. Fleischl, physician in Rome, politely informed us that Signor W., proprietor of the Villa Spada, on the Janiculan, had been attacked by a grave form of fever, at a time when such had not yet appeared in Rome. This was owing to a great disturbance of the soil near the villa, in immediate proximity to the bedroom of Signor W. (on the ground floor). These excavations had been made in soil rich in *humus*, which had long been used as a garden, and in a clayey soil lower down, where an orange plantation was being made. May 2nd we brought to the laboratory specimens of both kinds of soil, taken from below the superficial layers of soil, and made with them artificial marshes, as described in Chapter II., which were kept in an air bath at a temp. of 35°—36°. In water mixed with these soils were seen

very many self-moving oval corpuscles, of max. diam. 0·00095 mm., sometimes united in twos and threes, in rows which oscillated. In specimens of soil from the new Botanic Gardens on the Viminal, used for comparison, these bodies were found but sparingly, and never united in rows.

May 6th.—Nos. VII. and VIII., not previously employed for experiment, were injected with mixtures of these soils, from the artificial lakes, with water—No. VII., 6·4 cc. of fluid from clayey soil, and No. VIII., the same quantity from soil rich in *humus*.

No. VII. had in eight days four F. A., with ever-increasing temp. (1st, 39°·9; 2nd, 39°·8; 3rd, 40°·3; 4th, 40°·3, 40°.1, 40°·3). Even in the remissions the temp. went on increasing. In the next six days the fever assumed the quotidian type, and the max. rose gradually to 41°·1.

No. VIII. from May 6th to 16th showed much less marked temp. rises. The maxima oscillated between 39°·9 and 40°·05; the two first 24 hours, and others 48 hours apart.

TABLE OF WEIGHTS.

	VII.	VIII.	Observations.
May 6 ...	2,429 gr.	... 1,838 gr.	Injections practised.
,, 14 ...	—	... —	No. VII. had seven young ones, not weighed.
,, 16 ...	2,092 ,,	... 1,898 ,,	
,, 17 ...	—	... 1,878 ,,	
,, 19 ...	—	... —	No. VIII. had five young ones, weighing 214 gr.
,, 20 ...	1,965 ,,	... 1,719 ,,	
		+ 214 ,,	
		1,933 gr.	

May 20th, both killed. *Autopsy*, No. VII.—Spleen much enlarged (L. 56·3; B. 12·8; T. 3·5 mm.; I. S. 1,289), colour darker and consistence less than normal; small quantity of black pigment. Many ecchymoses of pleura, and in superior (in man, posterior) parts of lungs diffused hyperæmia and œdema. Right heart gorged with fluid blood. Injection sites normal.

No. VIII., spleen less enlarged (L. 49·0; B. 11·0; T. 3·0; I. S. 837). Normal colour and consistence; very few granules

of black, and considerable quantity of dark red pigment; sanguinolent fluid in pleural cavities; partial atelectasis of lungs with slight emphysema of lower (in man, anterior) border. Injection sites normal.

The results of these experiments point to the great difference of development of the agent in virgin soils, compared with those long under garden culture. It would seem as if the latter reduced the danger to a minimum, but one experiment with soils from one place is not conclusive.

GROUP IV. *Experiments with samples of soils of Agro-Romano.*—The soils used in these were taken from the farm of Valchetta (Cav. Francesco Piacentini). The first from a marsh situated on one of the hills. The second from a marsh near the hamlet. The third from a pasture lately broken up by the plough in the valley of the Cremera. All collected May 9th. A fourth from an artichoke ground was received May 17th from Signor A. Piacentini.

With the first three artificial marshes were farmed and kept at 30°—35°. May 14th a first experiment was performed with earth from the marsh near the hamlet. A portion was mixed with an equal volume of Marcia water,* and after the heavier particles had subsided 6·4 cc. were injected under the dorsal integument of No. XII., which had had a slightly subnormal temp. for six days, except on the 13th (Table V., curve XII.). After the injection the temp. rose to 38°·6, and then fell below the normal. 15th, about noon, it rose to 39°·9, and again descended below the normal, 38°·6. These brief and slight rises of temp. were not considered to be due to the injection, as a similar one had occurred the day before it was practised. It was used therefore in another experiment.

With soil from the hill marsh two parallel experiments were instituted, the injection fluid being prepared as before, and No. XII. was injected (May 16th) with 6·4 cc. It was then filtered through Swedish paper, and 6·4 cc. of the filtered liquid injected into No. VIII., already used in an experiment (see last group). After injection the temp. in No. XIII. rose to 40°·2, then fell below the normal. On the 17th, at 10 A.M., a second injection was used of an equal quantity of the filtered fluid.

* A very pure Roman water.

The temp. rose for a short time to 40°, but was not renewed. Animal killed May 20th. The filtered fluid had produced an intermittent fever, with slightly elevated maxima. In last intermission temp. subnormal.

No. XII., which had been simultaneously injected with an equal quantity of the same liquid *unfiltered*, had in 36 hours 3 F. A., with always higher max. and min. Two maxima reached 40°·8 and 40°·6, then rapidly diminished, and the last temp. registered (10 P.M.) was 39°·4. The night of 17th the animal died.

From 16th to 17th it had lost 166 gr. On the 16th it had one abortion, weighing, 30 gr. *Autopsy.*—Blood coagulated—a second abortion protruding from vaginal orifice. Suppuration at injection sites.

The usual oval self-moving corpuscles mixed with the pus cells in large quantity. Many filaments of *bacillus malaria*, some very long. Some of the joints contained spores.

Spleen much enlarged (Table I., fig. 12), it had reached dimensions never before witnessed by us in these malarious infections; L. 81·8 mm.; B. 19·4; T. 6·9; I. S. = 5,903, *i.e.*, almost eight times the normal. It was rather soft, but its angles and borders were not rounded; *the transverse section was triangular, the colour slate. In the splenic pulp examined fresh, were seen many oval self-moving spores, some bacilli. L.* 0·001 —0·002, *and even long or homogeneous filaments. Many cells of the spleen contain granules of black pigment. Even the bone marrow contained many self-moving spores and bacilli. In addition were found long and homogeneous filaments of the width of* 0·0006 *mm., and mean length of* 0·06 *mm., some reached a length of* 0·084 *mm.* All these observations were made with a solution of 0·75 per cent. of chloride of sodium in distilled water, freshly prepared, and in which a most careful examination failed to detect any trace of organisms. Without adding any liquid, however, we could observe these filaments in the bone marrow and the spleen. Professor Bizzozero, who was in Rome at the time, kindly assisted in these observations and measurements. The kidneys were very large, especially the left. Their upper surface was bounded by the limit of the inflammatory foci in the injection sites. The liver was dark-coloured and very large. The uterus contained four immature young ones. The right heart

was gorged with grumous blood. Both lungs œdematous with diffuse hyperæmia, and some recent ecchymoses. We here see rise up from the action of the liquid prepared from the hill marsh (which after filtering produced the weak infection in No. VIII.) a true pernicious fever, which killed the animal in 36 hours, and in the course of which, *bacillus malariæ*, diffused through the body, accumulated in the spleen and bone marrow, where it attained a very high development.* The doubts which might in this case exist, from the complication of suppurations in the back, will vanish from the study of the following case, in which the malarious infection produced by the same material ran its course without complication of any kind. This complication was probably due to the fact that the earth employed contained much excrementitious matter, and might easily cause suppurative inflammation. Of a liquid prepared in the same way from earth derived from the hill marsh of Valchetta unfiltered, were injected 6·4 cc. into the back of No. XIII. (May 14th, 8 A.M.), which had been under observation for three previous days, and not used in any other experiment. From the importance of the case, we think it well to give in addition to the temp. curve (Table V., curve XIII.) the table of figures.

TABLE VI.—*Temperature and Weight of No. XIII.*

Day.	Hour.	Temp.	Weight.	Day.	Hour.	Temp.	Weight.	Observations.
May 12	4 p.m.	39·5	1,567gr.	May 13	10 p.m.	39·65		
" "	6 "	39·35		" 14	6 a.m.	39 6		
" "	8 "	39·3		" "	8 "	39 5	1,481gr.	Injection.
" "	10 "	39·2		" "	10 "	40·5		
" 13	6 a.m.	39·3		" "	12 noon	40·1		
" "	8 "	39·7		" "	2 p.m.	41·1		
" "	10 "	39·3		" "	4 "	41·5		
" "	12 noon	39·5		" "	6 "	41·2		
" "	2 p.m.	39 9		" "	8 "	41·15		
" "	4 "	39·7		" "	10 "	41·2		
" "	6 "	39·3		" 15	6 a.m.	37·4		
" "	8 "	39·8		" "	8 "	—	—	Found dead.

* It is important to notice that the greatest malarious infections (XII., XIII., and XIV.) were produced by soil which had for three days been subjected to treatment, which, as we have said already, *impedes the development of algæ*, and arrests it at the outset in mud, in which it was most luxuriant, a fact which has an important bearing on the observations of Salisbury and Balestra.

Autopsy made immediately. Spleen much enlarged, soft, dark-coloured (Table I., fig. 13); L. 58·0; B. 14·3; T. 4·8. Having omitted to weigh the animal before opening it, the I. S. was calculated in reference to the animal's weight before the febrile *accès*. It was 2,124; *therefore it had become* 3·2 *times larger than the normal in* 24 *hours.*

The splenic pulp examined fresh contained *granules and irregular masses of brown and black pigment, very many automatically moving spores, some bacilli and long homogeneous filaments of a breadth of* 0·0006 *mm. and a mean length of* 0·07 *mm.* In the marrow of the bone were found many oval corpuscles, some of them enclosed in the large white cells, some of those free were double. Some self-moving oval bodies found in the blood of the portal vein and inferior vena cava.

In the lymph of the superior mesenteric glands were found very many oval spores and bacilli in abundance.

No other change was found in the other organs of the body.

The gravity of this case, in which, without any complication, a perniciosa even more intense than that which killed No. XII. with identical microscopic results, renders very interesting the comparison of it with No. VIII. In the latter the same substance was injected in equal quantity to that used for No. XII., and double that used for No. XIII., but the liquid was first filtered through paper, and this simple and incomplete filtration was sufficient to reduce the morbid power from the proportions it assumed in Nos. XII. and XIII. to the slender ones even in No. VIII.

The third sample of soil, taken from a field recently ploughed in the Val de Cremera, was derived from a non-marshy soil, which owing to the ploughing had been exposed to the action of air more than the two preceding. This circumstance made us suppose that the development of malaria might here have attained greater proportions, and this was borne out by the results.

No. XIV. not used before, and whose temperature had been normal for two whole days, was injected May 14th, at 10 A.M., with 6·4 cc. of a mixture of equal parts of Marcia water and the soil in question, after subsidence of the heavier particles.

TABLE VII.—*Temperatures and Weights of No. XIV.*

Day.	Hour.	Temp.	Weight in Grammes.	Day.	Hour.	Temp.	Weight in Grammes.
May 12	4 p.m.	39·3	1,421	May 16	10 p.m.	40·5	
" "	6 "	39·3		" 17	6 a.m.	40·7	
" "	8 "	39·3		" "	8 "	40·8	
" "	10 "	39·25		" "	10 "	40·6	1,309
" 13	6 a.m.	39·25		" "	12 "	40·8	
" "	8 "	39·2		" "	2 p.m.	40·7	
" "	10 "	39·0		" "	4 "	40·6	
" "	12 noon	39·1		" "	6 "	40·7	
" "	2 p.m.	39·4		" "	8 "	41·1	
" "	4 "	39·5		" "	10 "	41·3	
" "	6 "	39·3		" 18	6 a.m.	41·1	
" "	8 "	39·6		" "	8 "	41·2	
" "	10 "	39·5		" "	10 "	40·9	
" 14	6 a.m.	39·4	1,412	" "	12 noon	40·7	
" "	8 "	39·4 *		" "	2 p.m.	40·6	
" "	10 "	40·2		" "	4 "	40·7	
" "	12 "	39·9		" "	6 "	40·75	
" "	2 p.m.	41·25		" "	8 "	40·5	
" "	3 "	41·8		" "	10 "	40·4	
" "	6 "	41·3		" 19	6 a.m.	40·4	
" "	8 "	41·0		" "	8 "	40·4	
" "	10 "	40·9		" "	10 "	40·5	
" 15	6 a.m.	40·7		" "	12 noon	40·4	
" "	8 "	40 6		" "	4 p.m.	40·3	
" "	12 noon	40·4		" "	6 "	41·2	
" "	2 p.m.	40·8		" "	8 "	41·5	
" "	4 "	40·0		" "	10 "	41·2	
" "	6 "	40·7		" 20	6 a.m.	40·7	
" "	8 "	40·4		" "	8 "	40·6	1,345
" "	10 "	40·6		" "	12 "	40·1	
" 16	6 a.m.	40·1		" "	2 p.m.	40·5	
" "	8 "	40·0		" "	4 "	40·2	
" "	10 "	39·8	1,303	" "	6 "	40·2	
" "	2 p.m.	40·95		" "	8 "	40·0	
" "	4 "	40·2		" "	10 "	40·5	
" "	6 "	40·1		" 21	6 a.m.	40·9 †	1,373
" "	8 "	40·6					

* Injection, 6·4 cc. of liquid.

† Was killed.

This fever is one of the most characteristic in its course, and at the same time one of the gravest, produced by us, having a maximum temp. in the first F. A. of 41°·8, and in the third of 41°·5. And although it was so grave, the weight went on increasing after the first remission, but not much (70 gr.)

Autopsy.—Great poverty of blood in the entire organism, and this so pale that it could not be used to obtain the nature print of the spleen, so that the blood of No. X., killed the same time, had to be used instead. Spleen very large, soft, dark-coloured, triangular on section (Table I., fig. 14). L. 62·4; B. 12·8; T. 4·8; I. S. 2,793, *i.e.*, four times the normal; contained large

quantity of black pigment and self-moving oval spores, diameter 0·00095, but no bacillus or filament.

The oval corpuscles also existed in the marrow and aqueous humour of the eye, reserved for microscopic use to dilute other preparations.

The lymph was very rich in these oval bodies, of the superior mesenteric glands, which was charged with pigment. In classifying these soils according to their infective power, the lowest place must be assigned to that from the marsh near the hamlet, and this and the soil from the garden of the Villa Spada seems to indicate that culture and admixture of excrementitious matter diminish the infective energy. We therefore made another experiment with soil from an artichoke ground near the ploughed field of which the soil was used in No. XIV. Time not permitting the employment of the means used in that case, we contented ourselves with mixing it with an equal quantity of water, and used the liquid after subsidence of the heavier particles. Nos. XV. and XVI. (not used before, and of which the temp. had been normal for two days) were injected with 6·4 cc. of the turbid unfiltered liquid in the case of No. XVI., and of the same after passing through a double filter in the case of No. XV. (Table V., curves XV. and XVI.)

No. XVI. had three febrile *accès* in three days, with always diminishing maxima and increasing minima. The type being quotidian passing into subcontinuous remittent. No. XV. had one *accès* of 40°·15 of short duration, then for 14 hours a sub-normal temp. Afterwards three slight rises of 0°·1 or 0°·2 above the mean at irregular intervals.

This double experiment, while showing that the infective power of the liquid was diminished by filtration, also showed that it had been already much limited even before filtration, which may be cited in favour of the hypothesis, *that a judicious cultivation of the soil diminished the production of malaria, even in regions in which this production is greatest.*

We have the intention to undertake much more extensive and complete researches to endeavour to solve this problem.

Group V. *Experiments with specimens of earth derived from non-malarious places.*—We only had time for two experiments of this kind. It is very probable that the diffusion of these germs is greater than may be revealed by the existence

endemic malaria; and that they exist in many places where this is lacking, simply because the necessary conditions of complete development are not present. By artificially procuring these conditions, we may render infective samples of earth from places where malaria shows no influence on the human body.

These two experiments were made with soil from a garden attached to the Pathological Institute of the University of Prague. This earth was a disintegrated silurian schist, *in situ* for twenty years, manured for the two last years, but not touched this year, and therefore very compact.

With this soil an artificial marsh was made as before, and kept for four days at a temp. of 35°—40°. June 9th, a portion of this was mixed with water, in the usual way, and 10 cc. of the turbid liquid injected under the skin of the back of a large rabbit, No. XIX., weighing 2,479 gr.

The liquid was then passed through a double filter of Swedish paper, and 10 cc. injected in the same way into No. XX., which weighed 1,680 gr.

After the injection there arose in No. XIX. a fever, during which the temp. was much above the normal (Table V., c. XIX. and XX.). This continuous fever had after the first remission (39°·9) two recrudescences, during which the temp. ran up to 41°·1 and 41°·8. From the last up to its natural death, which happened when the animal had still a temp. of 40°·4, elapsed 22 hours.

In No. XX. after injection arose a fever, similar to a quotidian. The six accesses are divided into two groups of three each, separated by an intermission between the 3rd and 4th *accès*, in which the temp. fell from 40°·0 to 37°·5, to rise again during the 4th *accès* to 40°·3. No. XX. was killed when No. XIX. died, and the two autopsies made at once.

In No. XIX. a large abscess at injection site, grave pulmonary œdema; organs atrophied and poor in fat; spleen enlarged and soft.

In No. XX. general atrophy very pronounced; spleen very small. Both had lost weight largely.

	Weight.		
	At commencement.	At the end.	Loss.
XIX.....	2,749 gr.	2,285·5 gr.	463·5 gr.
XX.	1,680 „	1,175·5 „	504·5 „

	Size of Spleen.				
	L.	B.	T.	I.S.	
XIX.....	60·8 mm. ...	11·2 mm. ...	4·0 mm. ...	1,261	Normal Index,
XX.	30·8 „ ...	4·8 „ ...	1·6 „ ...	201	664.

In No. XIX. the fever was undoubtedly septic. In No. XX. probably hectic from septic infection, in which, as often happens in man, the temp. alternations resemble malarious quotidian.

Group VI. *Septic infections produced spontaneously in animals under experiment.*—In two animals introduced into the laboratory septic infection occurred before they had been used for experiment. In one, No. VI., the temp., at first subnormal, increased continuously till it reached, before the natural death of the animal (Table IV., curve VI.), the height of 40°·9. At the autopsy was found grave peritonitis with effusion of serum and masses of fibrin, produced by perforating ulcer of the large intestine; anæmia, with dense grumous clots in the heart; lungs extremely œdematous; spleen moderately enlarged, soft, pale red coloured, angles much rounded (Table I., fig. 6). It contained no pigment.

No.	Weight of Body.		Dimensions of Spleen.			I. S.
	Beginning.	End.	Length.	Breadth.	Thickness.	
VI.	1,236 gr.	1,057 gr.	53·00 mm.	9·0 mm.	4·6 mm.	1968
	Loss ..... 79 gr.					

The second was a large rabbit (No. XI.), which had fever when brought to the laboratory (Table IV., curve VI.). The temp. rose on the second and third days to 40°·0 and 40°·3, then came two short remissions; the fourth day it rose gradually to 40°·8. Abscess in neck opened. Gradual fall of temperature for two following days, perhaps helped by magnes. benzoate. Strong fever lasting six and a half days, until it was killed. Fever always high even in the remissions, except at the middle of the second day, when for a very short time it was subnormal. This animal during the fever ate enormously and gained weight a little.

Autopsy.—Spleen very large and soft, with rounded borders and elliptical section (Table I., XI.); no pigment; blood watery and colourless; pleura pulmonalis ecchymosed; lungs hyperæmic and œdematous; right heart gorged, left empty; an immense abscess in submaxillary, and extensive purulent infiltration in scapular region.

No.	Weight of Body.		Dimensions of Spleen.			I. S.
	Beginning.	End.	Length.	Breadth.	Thickness.	
XI.	2,578 gr.	2,655 gr.	79 mm.	13·8 mm.	6·5 mm.	2669
	Gain..... 77 gr.					

Supplementary Notes.

While the authors are aware that further and very extensive researches are required before the subject is exhausted, they claim to have proved—1st. *That malarious affections may be produced artificially in animals in the identical forms known to human pathology.* 2nd. *That these artificially-produced malarious affections are excited by organisms, which are found in the soil of malarious places before the appearance of the fevers, and are, even then, diffused in the strata of the air nearest the soil.*

Certain further facts, not fully set forth in the preceding, the confirmation of which was independently arrived at by Professor Marchiafava, call for statement.

1st. *Anatomical changes observed in animals in which malarious infection had been induced.*

a. The uniform, swelling, triangular section, sharp edges and borders, markedly distinguish malarious from septic enlargement, in which the organ is rounded.

b. The presence of black pigment, derived, as Marchiafava has shown, from the hæmoglobin of the blood, and containing iron in inorganic combination, as shown by the blue colour resulting from the reaction with weak hydrochloric acid and ferrocyanide of potassium. *Therefore it is indisputable that in malarious diseases hæmoglobin becomes decomposed even in the blood globules still intact, in such a way as to set free the iron which at first was united with other organic compounds, and could not be traced by this reaction.* The name *melanæmic*, by which it is distinguished, is therefore justified. In the greater part of our artificially produced cases this pigment was present. The largest quantity was seen in the spleen of No. XIV., in which recently ploughed earth of Valchetta was used, and in which severe fever occurred running up to 41°·8. The pigment was most abundant

in the peripheral parts of the spleen, and formed masses, large and irregular, or of a rounded contour, slightly smaller than a blood globule. The transformation of the hæmoglobin was, in the preparations, traced through all its stages, and also in those preserved in Canada balsam.

In No. XIV. only was melanæmic pigment found in any other organ but the spleen. Perhaps the brief duration of very severe fever in this case, and the slight gravity but long continuance of it in the others, explains this difference. Even in this animal, however, the pigment could not be seen except in the superior mesenteric glands, which were of a greyish brown colour. The pigment was chiefly accumulated in the lymph sinuses, where groups of granules were seen, some transparent and of a nickel colour, others opaque and black.

The perfect identity of these with those found in the spleen, the smallness of the pigment masses, the absence of transition forms, and the site of the accumulations, show that the pigment had not been formed in those glands, but conveyed to them after the disintegration of the pigment masses. Since neither the blood nor inferior lymphatic glands contain traces of this pigment, it cannot have been derived from the intestines or blood vessels, but must be supposed to have been imported into the superior lymphatic vessels by the lymphatics which connect them with the spleen.

In Nos. XII. and XIII. the amount of pigment was much less than in No. XIV. Of the two former, the spleen of No. XIII was richest in melanæmic pigment; although the duration of fever was shorter, the temperature and swiftly fatal course point to a severer form of infection than in No. XII. The greater proportion was found in the Malpighian corpuscles and in the vicinity of the arteries, probably owing to rapid introduction of pigment into the circulation, as we cannot admit that it had formed in these corpuscles, in which we never found any trace of pigmentation, not even in No. XIV., which had a *true black* spleen.

The two cases of septicæmia are directly opposite in this respect. In neither was any black, or even brown, pigment found in the spleen, but only large white cells full of small granules of an uniformly orange colour.

2. *Bacillus malariæ*.—We have described in Chapter III. the

principal forms of the plant found in the soil and air of malarious places, which, after cultivation, produced forms of disease exactly the same as those produced by the crude material which was the basis of cultivation; and it is sufficient to have shown experimentally that one determinate form of bacillus must be regarded as the exciting cause of the disease. It remains for botanists to determine what ulterior developments this organism may have, and all its biological attributes. We have stated how the commoner forms of *bacillus malariæ* proceed from homogeneous filaments often twisted or looped, which, when cultivated in fish gelatine, in egg albumen, urine, divide into joints, and produce spores in their interior both before and after this division. The situation of the spores varies; sometimes they are only found at the two ends of the articulation, at other times in the middle, and again at another time there may be a median spore and also two terminal ones—characteristics which distinguish *bacillus malariæ* from all other bacilli.

Some cultivations showed us very well the development of filaments from these spores when set free. In the oval shining corpuscles so often described, one of the poles is elongated into an appendix, which is slowly converted into a rod; sometimes in young spores one sees the clearing up of the substance of one pole precede the formation of the appendix; at other times the formation proceeds from both poles of the spore at the same time, leading to the formation of two appendices.

The rods elongating produce homogeneous filaments; sometimes two terminal spores are developed in the interior of these, or one median; in a few cases the spores are developed in their interior in such a way as to make one think that they are the products of the division *in situ* of a previously formed spore. Sometimes before the production of articulated filaments we see form in their interior some brilliant oval bodies (Table II., fig. 1, *d*), and the filament grows so rapidly that one can watch its increase with the eye, becoming full of small brilliant granules, whilst the oval spores fade away.

We are not in a position to decide whether the small granules are derived from the breaking up of the spores, or a multiplication of them due to a new precipitation of plasma.

This mode of evolution seems to be connected with certain forms seen by us in cultivation of the air of Ninfa and Fogliano

in urine, and of Caprolace mud in fish jelly. They are shown in fig. 8, Table II., as seen with 1-12 in. objective (oil immersion), and No. IV. eyepiece of Zeiss—jointed filaments, full of small shining granules (*a*, *a*, *a*). The division into joints commences in these filaments with the formation of a dividing membrane which separates the two masses of protoplasm. The extremities of these newly-formed joints are rounded, the distance between two contiguous joints becomes greater, and the uniting band so weak as to be readily severed. The granular homogeneous masses contained in the joints divide longitudinally or transversely, or both, producing spherules separated by clear spaces.

We are unable to say whether these forms belong to the normal evolution of this bacillus, or represent anomalies produced by the special accidents of our cultivation. The sum of our observations leads us to think that the forms of fig. 8 belong to this species of bacillus. Should further observations show the contrary, that would not change our conclusions, because in such a case we should regard it as an admixture with other forms of schistomycetes.

Fig. 5, Table II., shows exactly the advanced development of the plant seen in the serum of the lymph of No. I. This was enclosed, April 21st, in a microscopic air-cell. It contained oval self-moving bodies, some of which had two polar appendices, and some homogeneous, slightly oscillating filaments. Next day were found the forms of (fig. 4, Table II.), viz., free spores, twisted filaments, some of which had spores at the two ends.

April 23rd the development of filaments was enormously increased, the bundles forming a network.

So that from a liquid of the body of an infected animal were obtained, without the addition of any other substance, forms identical with those obtained by means of the first cultivation of the crude material and subsequent cultivations of the same.

Long homogeneous filaments, identical with those obtained by cultivations, were met with in the spleen of No. XIII., and in the spleen and bone marrow of No. XII.

3. *Bacillus malariæ in man.*

Dr. E. Marchiafava, first assistant to the Professor of Pathological Anatomy in the University of Rome, had an opportunity

of examining the bodies of three persons very recently dead of perniciosa. The autopsies were made with the utmost care to avoid sources of error. In the first, made July 25th, the examination of the blood was omitted. In the spleen and bone medulla no bacillary forms were met with, but only a large quantity of spores.

The second was made August 19th, on a man who died in the second *accès* of *perniciosa comatosa*, in the Santo Spirito Hospital. The spleen was doubled in size, brown, and very soft; the bone marrow brownish-red; the kidneys, liver, brain and its membranes rich in blood; the right heart full of fluid blood, the left empty; bilateral hypostatic congestion of lungs. No other change. The splenic pulp, juice of bone marrow, and of cæliac lymphatic glands, the blood of the splenic vein, hepatic veins, portal vein, and of the right heart, collected in capillary tubes, and sealed with the lamp. In the splenic pulp and bone marrow a small quantity of rusty pigment was found in free masses, or inclosed in the cell elements, a distinct quantity of oval spores, and some rods like those in fig. 1, *a*, Table II. In the lymphatic gland juice and in all the samples of blood were found a great quantity of bacilli, some homogeneous, others jointed and perfectly identical with those in fig. 3, Table II. Cultivation of splenic pulp and a few drops of blood in urine, in the usual way produced forms identical with figs. 5 and 6, Table III. In the third case, similar in every respect, there was in addition very grave general melanæmia; spleen doubled in size; pulp diffluent and black; bone marrow chocolate colour; liver lead colour, and grey substance of the brain slate colour. In the blood and throughout the body pigment masses free and inclosed in the white cells. In the blood, marrow, and spleen, very numerous oval spores, endowed with very active movements. In addition, in the spleen and blood oscillating rods like fig. 1, *a*, Table II., and nucleated bacteria like fig. 1, *f*, and fig. 7, *c*.

In the blood, everywhere, and in the spleen and marrow a very large number of long homogeneous filaments, some twisted like fig. 7, Table II., and long homogeneous and jointed filaments perfectly identical with fig. 5.

Dr. Valenti, Professor of General Pathology in the University of Rome, took part in some of these observations, and the

results of the last autopsy were verified by Professor Tommasi-Crudeli.

NOTICE TO THE READER.

THE original of this Paper is profusely illustrated by plates and temperature charts. The reproduction of these would have involved too great expense, and they have therefore been omitted. The references have, however, been retained in the translation as being useful to those readers who may wish to pursue the subject in more detail in the Author's own words.

The same statement applies also to the following Paper.

ON THE

ALTERATIONS IN THE RED GLOBULES IN MALARIA INFECTION,

AND

ON THE ORIGIN OF MELANÆMIA.

MEMOIR BY

PROFESSOR ETTORE MARCHIAFAVA AND DR. A. CELLI.

ON THE

ALTERATIONS IN THE RED GLOBULES IN MALARIA INFECTION,

AND ON THE

ORIGIN OF MELANÆMIA.

Of all the changes which malarious infection determines in the human organism, the most characteristic is that which takes place in the blood, and is called *melanæmia*.* This dyscrasia consists in the presence in the blood of brownish yellow or black pigment, rarely free, generally collected in the white cell elements. The existence of pigment in the blood is easily verified by examining a very thin film; and in the bodies of persons who have died from pernicious fevers a great abundance of pigment is found, free, or inclosed in the cell elements, in the blood vessels of the spleen, marrow, brain, kidneys, &c. When the melanæmia has ceased, there remains *melanosis* of the organs, *i.e.*, deposit of granules and pigment masses around the vessels and perilobular connective tissue of the liver, and in like manner in and around the lymphatics. The *melanosis* witnesses to the antecedent *melanæmia*.

The origin of this pigment has been by almost all authors derived from the colouring matter of the blood, but there has been no agreement as to the site or manner of its formation, as will be seen from the following *résumé* of the history of melanæmia.

The ancient school of physicians† held that sometimes black material was formed in the spleen and blood of the portal vein, capable of giving rise to diseases. The "black bile" formed an

* Melanæmia, so far as we now know, occurs only in malarious infection, and possesses characters so special that one cannot conceive how they have been confounded by some authors with the hæmorrhagic diathesis, Addison's disease, &c.

† Frerichs, *Clinic of Liver Diseases.*

essential part of their humoral pathology, and Galen held that [illegible] accumulated in the spleen and caused engorgement of the blood-vessels, destruction of the intestines, and serious disturbances of the nervous system. Leaving on one side, however, the views of the ancients about "black bile," we find that from the last century it began to be noticed that some organs showed a black or blackish colour in grave malarious fevers, so that Lancisi,* for example, speaking of the changes met with in persons dead from malaria, says: *Primum in iis qui ob tertianos perniciosas occiderunt, ingens malorum sedes sub aspectum venit in abdomine ubi omnia livida, et potissimum hepar subfusci, ac bilis cystica tri coloris passim occurrerunt.*

Mekel, however, was the first to observe pigment in the blood, and held that it passed from the spleen into the blood.

Virchow† discovered pigmented elements in the blood and spleen of a man who died of dropsy following repeated attacks of malarious fever. He believed the pigment to be derived from the spleen, and persisted in affirming melanæmia to be a dyscrasia of that organ.

Tigri saw and described melanosis of the spleen as "black spleen."

Frerichs‡ accurately described melanæmia and its effects. He observed black granules, pigment cells, masses of black granules held together by hyaline substance, delicate or dense, but always without fixed shape, and pigment masses, sometimes cylindrical with parallel facets, surrounded by a ring of pellucid substance. He believed the pigment formed in the spleen, and passed into the general circulation. In proof of this he adduced the following arguments:—

a. Pigment is found in the healthy spleen. *b.* In melanæmia the spleen is always more largely charged with pigment. *c.* Pigmented epithelium of the spleen is found in the general circulation.

He believed that the liver shared in this power of forming pigment. He confirmed the view of Virchow that in intermittents pigment forms in the spleen and passes into the circulation.

Colin§ holds, on the other hand, that this formation is not

* *De noxiis paludum effluviis eorumque remediis.* Roma, 1727.

† *Cellular Pathology.* Berlin, 1881.

‡ *Loc. cit.*

§ *Traité des fièvres intermittentes.* Paris, 1870.

confined to the spleen but occurs also in other organs, and has no specific character, because it happens, for example, in the mesenteric lymphatics in typhus and dysentery. In malarious fever, however, the destruction of the red globules is more rapid and remarkable than in other infectious diseases.

Mosler* is inclined to admit the doctrine of Virchow and Frerichs, of the primitive formation of pigment in the spleen. He holds that the peculiar structure of this organ predisposes to this pigment formation, that is to say, that the blood flowing from the capillaries into the intermediate vessels often stagnates, so that conglomerations of red globules occur, which are gradually converted into pigment.

Arnstein† rejects the doctrine of Virchow, &c., and maintains that the pigment is formed in the circulating blood during the fever *accès*. He says the pigment is found free in the blood when the fever has proceeded for a short time, and that in the majority of cases it is met with in the white cells. He examined the organs chiefly melanotic. In the spleen he found pigment round the arteries, capillaries, and veins, and in all these enclosed within the white cells. In recent cases only he found it in other organs.

He maintains that the view of Virchow and Frerichs is destitute of any support from facts. On the other hand, he regards the melanæmia as primary, and the melanosis secondary; and this chiefly because the melanæmia can only be found shortly after the febrile attack (which is unintelligible if the melanosis of the spleen was primary), and because the disposition of pigment in the circulating blood corresponds perfectly to what happens when colouring matter like cinnabar is introduced into the circulation. According to Arnstein, therefore, the red globules are destroyed during the fever paroxysm, the pigment formed from them is immediately taken up by the white globules, which stagnate in the veins and capillaries of those organs in which the current is feeble, viz., the spleen, bone marrow, and liver. The pigmented white cells are deposited in the tissues of those organs, whilst they linger longer in the capillaries of the liver. As to the mode of formation of the pigment he says he knows nothing, because the process of destruction in the red globules is too rapid to be

* Ziemssen, *Handbuch*, T. 8, Part. Milzkrankheiten, 1874.

† *Bemerkungen über Melänemie und Melanose.* Virchow's Archives, T. 61.

followed. He admits that it may occur in the serum of the blood from the hæmoglobin issuing from the red globules. He does not believe it is formed in the white cells, according to what Longhaus has observed in hæmorrhage, because free pigment is found in the circulating blood and globuliferous cells are not. The latter, however, are found in the spleen and marrow, but are few in comparison with the enormous quantity of pigment which exists in the blood.

Mosler,* in a later work, does not agree with Arnstein, that the pigment is only found after a febrile *accès*, and that it is erroneous to hold that its formation takes place in the spleen. He cites the case of a man affected with malarious fever, in whom the pigment was present, not only during, and shortly after the febrile paroxysm, but several months afterwards.† He persists in maintaining that it takes place only in the spleen, or that at least it happens in this organ more rapidly and abundantly in consequence of severe congestions.

Lanzi and Terrigi‡ notice the great analogy between the pigment granules found in the blood and organs in melanæmia, with those which exist in marsh soils, and especially in the cells of marsh algæ, and suspect that they are identical.

Kelsch,§ in a very accurate work, sums up the observations made in 1881 on the sick in the Hospital at Philippeville. He was chiefly occupied with the histology of the blood and organs. He found in the blood a diminution in the number of red globules computed by the method of Melassez. He observes that few maladies produce so rapid and serious an oligocitæmia as malaria; twenty or thirty days of quotidian or tertian suffice to lower the number of red globules in a C. mm. from five millions to one million, or even less than half a million. The rate of diminution in the number of red globules has its maximum at the outbreak of the disease, and goes on diminishing as the oligocitæmia increases, and the febrile attacks become more distant. In the cachexia the number of red globules becomes almost stationary. Kelsch found, in addition to this diminution of red globules, the presence in the blood of pigment granules, free or inclosed in

* *Über das Varkommen der Melanëmie.* Virchow's Archives, T. 61.

† Cases, analogous to this narrated by Mosler, are seen in our hospitals. See *Raggualgio di due Turni di Clinica Medica di Roma di Professor C. Maggiorani*, 1878.

‡ *La Malaria ed il Clima di Roma.* Rome, 1877.

§ *Contribution à l'anatomie pathologique des maladies palustres endémiques.*

hyaline masses, but oftener in the white cells. The melaniferous elements enclose 3—6 granules, sometimes massed in a series like a crown in the periphery of the cell. Besides these, others are met with which present a brownish reflection accentuated in the marginal zone, in which are sometimes found very fine black granules, and in the blood of the splenic and portal veins he observed the presence of melaniferous cells, very variable in form and size, viz., spherical, polyhedric, ovoid, elongated, biscuit-shaped, &c. From observations of the organs he comes to the conclusion that melanæmic pigment is deposited absolutely in the same way as an artificial pigment, injected into the veins, either free or enclosed in the cells. As to the mode of formation of pigment he rejects the doctrine of Virchow and Frerichs.

In one case of "perniciosa fulminante" he found little pigment in the spleen, but the blood very rich in it. He therefore believes it is formed in the circulating blood. He is, however, unable to accept that some melaniferous cell elements represent the stroma of decolourized blood globules with pigment granules, formed at the expense of the hæmoglobin, because he has not met with the intermediate stages of this retrograde metamorphosis. Nor does he admit the intracellular formation of the pigment, with Longhaus, because it is also met with free in the blood. He therefore takes refuge in the hypothesis, that the melanic material exists in the serum in a state of solution, and proceeds from the destruction of the red globules; this material precipitates, when the blood is saturated with it, under the form of granules, which are quickly included in the white cells, as happens when cinnabar is injected into the blood.

One of us (Marchiafava*) studying the splenic pulp and bone marrow of melanæmic children, found red globules generally inclosed in white cells (globiferous cells), which exhibited a varied colouring, which passed from a brownish yellow to a more or less intense black, presenting the appearance of black spherules of a diameter somewhat less than a red globule. He concludes, therefore, that the red globules do not give rise to the formation of pigment after their destruction, but that the conversion of hæmoglobin into pigment occurs gradually within them.

Klebs and Tommasi-Crudeli,† studying the changes in the

* *Commentario Clinico di Pisa.* Gennaio, 1879.
† *Sulla natura della malaria.* 1879.

spleens of rabbits in which they had produced malarious fevers artificially, found red globules, at first nickel-coloured and preserving their discoid shape, afterwards of a black colour, and inclosed singly or in groups in the white cells, with the destruction of which they became free and reduced into masses. They conclude that the conversion of hæmoglobin into black pigment takes place in the red globules while they yet retain their semi-fluid consistence.

Tommasi-Crudeli* also holds that this degeneration of red globules occurs throughout the whole vascular system, and chiefly in the vessels of the spleen and bone marrow. He says that in melanæmia takes place a *necrobiosis* of red globules, produced by a specific degenerative atrophy of their protoplasm.

Afanassiew† made his observations on the sick amongst the troops in the last Russo-Turkish war. He describes the affection of the spleen, kidneys, liver, and brain in those dead from malaria. His description is in accord with other observers as regards the spleen, liver, and kidneys. In the brain he found distinct cloudiness of the protoplasm of the nerve cells, with enlargement of the pericellular spaces; the capillary walls sometimes granular; the endothelium swollen; pigment granules in the lumen of the vessels, in the endothelial cells, in the perivascular areas. He describes such granules when they are isolated, and not formed into masses, as perfectly round, of equal size, and having a shining brown centre. He doubts their origin from the colouring matter of the blood; suggests that they may have another origin; finds that they have an analogy with the *cromigenous micrococci* of Cohn, and suspects their parasitic nature. With the history of melanæmia are connected some recent researches of Laveran and Richard.

Laveran‡ holds that the pigmented elements described in part by Kelsch, and different from melaniferous white cells, represent parasitic elements. He describes three forms of these pigmented elements, which he holds to be of parasitic nature. 1st. Elongated elements, threadlike at the ends, almost always curved like a crescent length 0·008—0·009 mm.; mean breadth

* *Institutes of Pathological Anatomy.* Turin, 1882—4.

† *Beitrag zur pathologie der malaria infection.* Virchow's Archives, 1881.

‡ *Nature parasitaire des accidents de l'impaludisme.* Paris, 1881. Comptes rendus (1882).

0·003; their contour marked by a very fine line; the body transparent except in the centre, where there exists a spot formed of blackish granules; often on the concave side is seen a fine line uniting the two extremities of the half moon.

2nd. Spherical transparent bodies, of the mean diameter of a red globule containing pigment granules, which in repose often describe a very regular circle, and when in movement are actively agitated. Sometimes at the periphery of these elements are observed very fine filaments, which are apparently inserted into them, are animated by very rapid movements, and have the free extremity slightly swollen. Such filaments may be detached, and move freely in the midst of the red globules.

3rdly. Spherical elements, of irregular form, transparent and finely granular, diameter 0·008—0·010 mm., containing pigment granules disposed very irregularly at the periphery, sometimes collected in the centre, sometimes at a point of the periphery itself.

There are also found in the blood, according to Laveran, spherical transparent elements, containing movable and immovable pigment granules, elements of smaller diameter than the preceding, isolated or united, and adhering to the red discs and the leucocytes.

Laveran believes that these pigmented bodies represent different stages of an elementary parasite, which he is unable to pronounce to be animal or vegetable, which exists in an encysted condition, and in its perfect form becomes free as a *movable filament.*

Besides these, Laveran has observed in the blood shining, round, movable bodies, without specific character; melaniferous leucocytes, red globules which appear perforated in one or more points, inclosing pigmentary granulations, free pigment granules resulting from the destruction of the parasitic elements.

Richard* confirms fully the observations of Laveran, but instead of holding, like this observer, that the small pigmented forms are found adhering to the red corpuscles, he maintains that they, existing within the latter, where they are developed, grow and issue from them in a perfect state. He describes these pigmented parasites in various stages of development in the red globules, when arrived at a state of maturity perforati

* *Sur le parasite de la Malaria.* Comptes rendus (1882).

the membrane (?) of the red globule, and becoming free in the blood, presenting themselves thus sometimes furnished with movable filaments, like the bodies described by Laveran.

Both these last observers note that, in the organs of those dead from grave malarious infection, these supposed parasites are recognized by the *pigment*, which is arranged in circular series at their periphery.

It is right to observe at once that both these authors are entitled to the credit of having called attention to the pigmented elements, already to some extent noticed by others (Frerichs, Kelsch, &c.), which are not white cells of the blood; and to the second, viz., Richard, of having shown that the pigmented bodies are found in the red globules.

From this *résumé* of the history of melanæmia, it is clearly seen how the opinions of authors vary, not only as to the place of formation of pigment, but the precise way in which it is formed.

There is another category of authors, of whom some suspect the parasitic nature of the pigment granules; others hold these as partly constituting the parasitic element. It is therefore of some importance to return to the accurate study of melanæmia, and employ the means which the microscope has lately placed at our disposal.

This research could not be made with all the completeness desired, because for some years the malarious infection has in Rome and the Roman Campagna become mild, and consequently the grave forms of malaria have not been frequent in the hospitals, where, however, the slighter forms of intermittent abound. This diminution in the severity of the malarious infection has been further confirmed in the anatomical rooms, where in the bodies of peasants dead from other diseases it does not happen so frequently as in the past to meet with melanosis of the spleen, liver, and bone marrow—the melanosis which testifies to antecedent melanæmia.

The researches which we now describe were made in the blood of fever patients, taken at the Santo Spirito Hospital from July to the middle of October, 1883.

The method of examining the blood adopted by us was as follows:—

The blood was taken from a puncture, or small incision with a

ancet, in the finger of a fever case at different stages of the attack. The skin was previously washed with alcohol, and allowed to dry by evaporation. The first drop of blood was removed, and the succeeding ones used. On a drop of blood which welled from the wound a covering glass was delicately applied, so that a very small quantity might be deposited upon it; this was afterwards rapidly compressed against another covering glass, and they were then made to slide one upon the other, so that upon each remained a very thin film of blood, which was dried by passing it two or three times through the flame of a spirit lamp. Afterwards were dropped upon the preparation one or two drops of a recently filtered solution in alcohol and water of *methylin blue*, and after a few minutes washed thoroughly in a vessel containing distilled water, dried again, and the preparation mounted with oil of cloves, of citron, and balsam; the method being that used by R. Koch and P. Erlich.* The microscopic examination was made with a 1-12 in. (homogeneous immersion) lens, Zeiss.

We now set forth the result of the observations.

The normal red globules are stained faintly blue, and if the solution has only acted for a short time, or perhaps according to the degree of desiccation, remain of their usual yellowish colour.

The white globules exhibit a pale blue staining of their protoplasm, and an intense staining of the nucleus. The "*piastrine*"* are stained blue, a little less pale than the protoplasm of the white cells. But in the blood of persons affected with malarious infection, are found in the midst of the normal red globules, other red globules, which present alterations in their protoplasm, most evident in those which are not stained blue. These alterations consist in the presence within the globule of corpuscles in varying number, of different size and form, which are conspicuous from their more or less intense blue colour, always sufficiently to be distinguishable readily from the protoplasm, coloured or not, of the red globules. These corpuscles, advancing from the smaller to the larger, are seen—

(*a*) As granules, generally round, which are stained uniformly and more or less deeply blue, and often resemble micrococci. Of these one or more are found in a blood globule; in such

* *Elementary Granulations* (Bizzozero). *Blutplättchen* (German), a third cell element in the blood, according to Bizzozero.—E. D.

cases about two-thirds of the red globules present one, two, rarely three or four, of these corpuscles. Their size varies; some appear as very small granules, and others as a large micrococcus.

(*b*) As corpuscles larger than the preceding, with a vacuole in the centre so as to represent rings, more or less large and delicate. Of these rings some are found large enough to occupy one-third, or even one-half, of a red globule, sometimes spherical, sometimes oval, irregular or dentated, sometimes having a fine prolongation which terminates free in the protoplasm of the red globule or unites with an adjacent ring. One, two, three, or even more such are found in one blood globule.

(*c*) As corpuscles larger than the first, uniformly stained or with vacuoles, in form spherical, oval, spindle-shaped, semi-lunar, triangular, sometimes forming irregular masses which present in their interior granules or masses of black or rusty black pigment. The larger masses invade, in some red globules, all the protoplasm coloured by hæmoglobin, of which there remains either a delicate outline or a more or less subtile rim at some point of the periphery, scarcely visible with the most careful examination. Besides the red globules thus altered are found coloured bodies like the masses described, rich in clusters and granules, spherical, oval, irregularly semi-lunar. These evidently represent the last stage in the alteration of the red globule, which is thus converted into a body devoid of hæmoglobin, stainable with methylin blue, and containing pigment. Besides these red globules, of which the phases of change may be followed up to their conversion into a pigmented mass, there are found in preparations fragments of the latter in various forms, always pigmented, and white globules, in whose protoplasm pigment is found in granules and larger clusters than those found inclosed in the red globules.

If the blood issuing from the wound is mixed with a drop of pure distilled water, and then dried as in the first method, there are seen, together with normal red globules, which have lost their hæmoglobin and are only marked by a faint outline, others which have also lost their hæmoglobin and are distinguished by this faint outline, but which contain in their interior the corpuscles mentioned, stained deeply blue and clearly defined.

We have stained the blood with other aniline colours, acid and

basic, and here is the result. With *eosin* the corpuscles are stained pale rose, while the rest of the red globule is intensely yellowish red; the pigment remains unchanged. With *vesuvin* they stain red-brown. With *tropæolin* they are not stained at all, but are recognized, in the red globule stained a beautiful clear yellow, as so many spots containing pigment or not.

Examining the fresh blood without any treatment, we see only the larger corpuscles appear as colourless and pigmented specks, as already described by Richard. The red globules in which are found the corpuscles (small, round, analogous to micrococci) appear normal, or if there are specks, these are indistinguishable from the lacunæ which are formed accidentally in normal red globules.

The pigmented spots present various shapes, increase gradually, and coalesce, so that the entire red globule is converted into a decolorized body of hyaline aspect, containing granules and masses of pigment. When it contains one or two pigmented corpuscles and still retains a distinct portion of its coloured protoplasm, it preserves its normal elasticity. When it is converted into a hyaline mass it sometimes preserves its elasticity; sometimes this is diminished, and the globule adheres to the slide or covering glass, does not move, or only moves slightly when pressed.

The pigmented granules, which are found in the spotted globules as well as in those completely decolorized, assume various figures when the globules move, viz., circles round the periphery of the specks, circular groups or irregular forms. When the globules are at rest, the pigment granules are motionless or move actively, especially those found in the serum on the blood clot.

In preparations of fresh blood other forms of red globules are encountered, viz., such as present only one half decolorized and of a semi-lunar form, having in the centre or at a point of the periphery clusters of pigment; or such as have lost wholly or partially their hæmoglobin and exhibit in the centre a single spot of black pigment, rounded, irregular, having somewhat the shape of an embryo.

In addition are found round, hyaline, or irregularly pigmented bodies and richly pigmented white cells. On adding distilled water, the altered red globules first become shapeless, and

then assume a perfectly spherical figure, like the other red globules.

With the reaction of acetic acid and alcohol these altered red globules are recognized by the pigment which they contain; with liquor potassæ the pigment dissolves slowly after ten to fifteen minutes. Ferrocyanide of potassium and hydrochloric acid do not produce their characteristic reaction on the pigment.

Such is the result of the examination of the blood in persons affected with malarious infection, especially during the fever paroxysm.

Is this alteration of red globules always found in malarious infection? To this we must reply, that if in many cases the altered blood globules are very numerous, in others they are very scarce, so that it is necessary to make many preparations in order to find them; in other instances they have not been found at all. The latter has been the case in simple intermittent, and in some forms held clinically to be graver manifestations of malaria.

In *comatose pernicious fevers* terminating fatally we have always found it, as also in the *sub-continued* forms.

When we have found such appearances in the red globules the individuals always presented a peculiar aspect in the course of the disease, viz., the skin became rapidly *earthy yellow*, the weakness was extreme, and the strength re-established slowly and with difficulty.

The relation of the degree of alteration of the blood to the clinical course of the infection will be an interesting subject of study.

We come now to speak more particularly of the alterations found in the blood and organs of persons dead from pernicious fevers.

We shall only speak of the cases which have occurred this year, *i.e.*, after we had studied the alterations in the red globules during life, and give them as a whole, prefacing a note of the history and examination of the blood before death.

1st Case. *Algide Pernicious Fever.*—R. D., ætat 25, entered the hospital August 11th, suffering from intermittent fever (quotidian), and had several paroxysms in the hospital. 14th, at evening visit in a state of profound collapse; skin very cold, cyanotic, and pulse almost imperceptible. Hypodermic injec-

tions of quinine, which had been administered internally on previous days. Died next day at 2.45. A.M.

Examination of the fresh blood during life showed numerous white globules much pigmented, red globules not visibly altered.

After staining, many red globules showed in their interior, one, two, rarely three corpuscles, of which a few were small, and more or less deeply stained, others somewhat larger, with a vacuole in the centre, appeared as blue rings.

Autopsy (7 A.M., same day).—Persistent cadaveric rigidity. Skin pale; brain and meninges exsanguined; grey substance pale; heart normal; myocardium greyish red colour; lungs slightly œdematous; spleen doubled in size, with numerous recent peripheral hæmorrhagic infarcts; parenchyma soft and dark red; liver normal in size, with icteric staining of central parts of lobules; kidneys, capsule readily detached, surface greyish, *glomeruli* not prominent, pale, substance of convoluted tubes yellowish grey; numerous hæmorrhages of the pelvis and calices; stomach, mucous membrane swollen and hyperæmic, with numerous scattered hæmorrhages; intestine normal; bladder dilated.

The blood of various vascular areas and from the splenic pulp and bone marrow collected, and stained preparations made. These showed under the microscope numerous red globules, containing the corpuscles observed during life; some larger ones containing pigment; numerous nucleated red globules.

The microscopic examination of the various organs hardened with alcohol, and stained with Bismarck brown or methylin blue, showed in blood vessels, chiefly in the capillaries, the corpuscles described, deeply stained; if the red globules are recognizable by their contour, these corpuscles are seen distinctly inside of them; but if the globules were disintegrated and reduced to the well-known yellowish-grey *detritus*, the corpuscles were equally distinctly seen scattered through this *detritus*, and therefore not destroyed like the red globules. In the capillaries of various organs, and chiefly the brain, these corpuscles were at so regular a distance from each other as to make it evident that they were still within the red globules, even when the contour of these was indistinct. In all the vessels were found in addition pigmented white globules and pigmented bodies stained blue, representing the last change of red globules.

2ND CASE. *Comatose Pernicious Fever.*—P. E., ætat 40, entered the hospital September 29th, in the afternoon, in an *accès* of comatose perniciosa. There was no previous history, only that he came from the Campagna. He died next morning.

Microscopic examination showed scattered pigmented white cells; red globules with pigmented corpuscles; numerous hyaline bodies of different shapes, spherical, oval, fusiform, semi-lunar, containing granules and pigment masses. Some of these hyaline bodies had at their periphery a zone of protoplasm coloured with hæmoglobin; a certain semi-lunar form was the result of the conversion of one-half a red globule into a pigmented hyaline mass, whilst the other remained decolorized, and only its delicate outline was visible. The examination made shortly before death showed a great number of pigmented white globules.

The stained preparations presented numerous red globules containing round corpuscles either in centre, at periphery, uniformly stained, with a vacuole in the centre, or blue rings of various size and form.

Autopsy (7 hours after death).—Œdema of the membranes; punctiform hæmorrhages of white cerebral substance; grey substance dark red; bilateral pulmonary œdema; hydrothorax; hydropericardium; heart normal; myocardium brownish red colour; spleen triply enlarged, of triangular form, very soft, of a chocolate colour; liver dark grey colour; lobules indistinct; kidneys dark grey colour, exsanguined.

The result of the microscopic examination was the same as during life. As to the examination of organs hardened and stained, it deserves to be recorded that the capillaries of the brain were distended with red globules, containing the corpuscles mentioned, deeply stained, and without trace of pigment. The pigmented white globules were rarely met with in these capillaries.

3RD CASE. *Comatose Pernicious Fever.*—M. L., a carter outside the Porta Maggiore, entered the hospital at 10 A.M., Oct. 6, already profoundly comatose and with high fever; said to have suffered some days from fever, and found that morning in this condition in a stable. After injection and internal administration of quinine he rallied somewhat, reacted to cutaneous stimuli, but did not recover his senses. After a little he sank into profound coma. Had very grave dyspnœa; pulse 140; temperature

39°; dirty yellowish-grey colour of the skin; spleen swollen and tender; tracheal râles. Died at 6 P.M.*

Examination of fresh blood: white pigmented globules in great number, a few red globules with clear spots containing granules of black pigment. Examination after drying and staining: in about half the red globules were found either corpuscles perfectly spherical, stained intensely blue, or larger ones with a vacuole in the centre, presenting the aspect of rings of varying size and shape, some furnished with a prolongation terminating free or united to the next ring.

Autopsy (12 hours after death).—Body that of a robust man, well nourished; colour of skin livid yellow; ocular conjunctiva slightly icteric. On the internal surface of the dura mater corresponding to the right frontal lobe were found two clots inclosed by delicate membranes furnished with numerous small blood vessels. Two other hæmorrhages having the same characters corresponded to the left central convolutions.

Hæmorrhagic infiltration of the *meninges* of the occipital lobes; punctiform hæmorrhages of centrum ovale of occipital lobes; grey substance leaden red colour; grey substance of the ganglia presented the same in a minor degree, as did the grey matter of the pons, bulb, and spinal marrow; heart normal form and volume; myocardium brownish, lacerable; lungs congested and œdematous posteriorly; spleen triply enlarged, capsule tense, parenchyma dark chocolate, very soft; lymphatic glands of the hilum dark red, swollen, very soft; kidneys pale, flaccid; stomach and duodenum with numerous mucous hæmorrhages; liver normal size, rich in dark blood; surface on section lavender red; gall bladder turgid with bile; intestines normal, except last part of the ileum, which presents spots of hyperæmic hæmorrhage, and soft swelling of the agminated glands; bladder, small quantity of turbid urine, containing, as found on chemical examination, albumen and bile pigment, red and white blood cells, granular casts of varying size, some convoluted.

Microscopic examination, same results as during life, but the corpuscles contained in the red globules more numerous. Splenic pulp and bone marrow rich in more or less altered red globules,

* Professor Marchiafava and Dr. Ferraresi have not unfrequently found such cerebral hæmorrhages, which explains the fact that hemiplegia is often left behind after attacks of comatose perniciosa.

and the latter contains a remarkably large number of nucleated red globules.

Spleen and marrow of these corpses served also for ascertaining if the black pigment which they contained gave the reaction with iron which had not resulted from the same pigment inclosed within the red globules. We used as the re-agent a solution of ferrocyanide of potassium (1 in 12) slightly acidulated with pure hydrochloric acid. Small fragments of melanotic spleen, dissected out with glass needles, and placed under the microscope with a drop of the re-agent, showed the reaction in some red globules, in very many white ones, in many globuliferous cells, of which some have only diffused staining of the protoplasm alone; others show the same reaction in the inclosed globules.* But nevertheless, after twenty-four hours of the reaction, the bulk of the granules and pigment masses lost their proper rusty black colour. The treatment was repeated with the same negative result in the liver and brain containing pigment. In these, however, was found a slight blue staining of the corpuscles inclosed in the red globules, whilst their contained pigment remained unaltered. The reaction was not assisted by a gradual increase of temperature up to 80° C. Perls† had already observed that all the black pigment in the liver and spleen did not give the iron reaction, as it was not given by the bile pigment, hæmatoidin, the choroid pigment, and its homologue in retinitis pigmentosa.

From these three characteristic cases of malaric infection terminating fatally we have a confirmation of the existence of the alteration of red globules, especially from the fact that the capillaries of various organs, above all the brain, were seen to be gorged with red globules containing corpuscles, in two instances almost all primary, round, small, and not having any pigment granules.

It is noteworthy also that these corpuscles were not free, but, on the contrary, always enclosed within the red globules, and only appearing free when their contour was lost after the action of alcohol.

From what we have stated, it is clearly shown that in malarious

* Compare *Studi pathologici e chimici sulla fanzione ematopoetica.* Tizzoni e Fileti. Trans. R. Acad. Liucei, 1880—81, vol. x.

† Virchow's Archives, T. 39.

infection there occurs a change in the red globules, which can be followed in all its phases; which begins with the presence of granules or corpuscles, generally spherical, stainable with any aniline dye, progressing with enlargement of these bodies, with their fusion, and the formation of blackish pigment in the form of granules and clusters, and ending in the reduction of the red globule into a pigmented body of a hyaline aspect, which is afterwards destroyed, and the pigment, set free, is inclosed in the white cells, and by them deposited in certain organs (spleen, bone marrow, liver).

Now what is the nature of this change in the red globules? That the change is to be regarded as of a retrogressive nature does not admit of doubt. We may, with Tommasi-Crudeli, define it to be *a necrobiosis of the red globule*, in which takes place the transformation of its *hæmoglobin* into *melanin*, whereby it only remains as a circulating *cadaver*, incapable of fulfilling its very vital function. This admitted, it may now be decided in reference to the site of formation and origin of pigment in melanæmia, 1st, *that the pigment is formed within the blood vessels and in the circulating blood;* 2nd, *that it is derived from the colouring matter of the red globule, and is formed absolutely in the protoplasm of the same.* The first conclusion is evidently admitted, that the pigment is formed in the circulating red globules, and agrees with what had already been established by Kelsch and Arnstein. It is intelligible from this reason alone why the hypothesis that the pigment is formed from extravasations of blood in the spleen and other organs cannot be received. The second conclusion is not less obvious, because whilst the red globule is decolorized, the black pigment is deposited, and this decolorization and pigmentation may be followed in all their phases.

Kelsch, as already mentioned, surmised that many of the pigmented forms represented decolorized and pigmented red globules, but abandoned this idea because he did not succeed in seeing all the steps of the pigmentation, and thought that the pigment was formed in the blood plasma from dissolved hæmoglobin.

As to the cause of such necrobiosis of red globules, we cannot at present say anything definite, any more than we can of other degenerations and necroses of elementary organisms in other

This book is the ...
COOPER ...

infectious diseases. To say that malaria attacks and determines the destruction of red globules, is only to repeat what clinical observation has already established. Bacelli* in fact long ago said that malaria struck not only the ganglionic system, whence the congestive processes from vasomotor paralysis, but also undermines the existence of the red globules, which lose their functional activity and perish. Besides the changes in red globules described by us, some other peculiarities seen are deserving of attention. The commencement of the change is indicated by the appearance in the red globules of granules and corpuscles generally spherical, which are deeply stainable by any aniline dye. Might these corpuscles represent micro-organisms which invade the red globules and penetrate their protoplasm?

No hypothesis could well be more seductive, but these characters do not suffice to make it acceptable. The granulations of the *mastzellen* of Ehlich present characteristics analogous to micrococci, and are yet only granulations of the protoplasm.

We have tried to settle the question by trying to cultivate the blood of the malarious, to see if these corpuscles would be multiplied.

The first attempts made had no result. Thus the cultivation of blood in Koch's gelatine produced no result, although the surrounding conditions were varied in many ways. The temperature of the hot box was, in the first experiments, maintained at fever heat; but in later experiments was, by the advice of Professor Filehne, who happened to be in Rome, kept at the normal of the human body, and gradually lowered to below 30° C. Blood was selected for cultivation in which the red globules showed the commencement of change, viz., very small corpuscles. The other conditions necessary for success were in the greater number of instances well attained, but round the little drops of blood and elsewhere not the slightest development of micro-organisms took place. Under like circumstances no result followed repeated cultivations, made in ossihæmoglobulin, prepared according to the directions of Hoppe Seyler and furnished by Professor Rossoni. After the failure of these attempts, others were made on the assumption that these supposed parasites might require, in order that their development might be

* La Perniciosa. Clinical Lectures, 1869.

seen, to be furnished with a soil of cultivation analogous to that of the red globule.

The necessity for using sterilizing temperatures, without at the same time altering the hæmoglobin, led to these ending in failure.

Finally, by a long process, resulted the preparation of a solid soil of cultivation answering to the conditions mentioned. In this was placed a drop of blood, taken with every precaution from the finger of a young man in the commencement of the cold stage of an ordinary intermittent. The hot box was kept at 36°—36°·5. During the first three days no change was seen round the tiny drop, but on the fourth day began to be seen a greyish-coloured halo, which was, on examination, found to be composed of round corpuscles of varied size, the larger colourless in the centre and resembling rings. Notwithstanding the apparent identity of the forms seen in the cultivation with those found in the blood of certain cases of perniciosa, we do not think any conclusions can be drawn from them. We only refer to the fact, which requires further research for its elucidation.

After the researches of Klebs and Tommasi-Crudeli,* bacillary forms were described by one of us (Marchiafava) and Cuboni as existing in malarious blood, swollen at the extremity and sometimes also in the middle, of varied length, and endowed with very active wriggling movements and locomotion. Afterwards the same forms were described by Marchaud† and by Ziehl.‡

Marchaud found in the blood of a fever patient bacillary forms with slightly swollen extremities, having about half the length of a red globule, and endowed with active movements. Ziehl found in the blood of three fever patients small bacillary forms, swollen at the ends, moving gently, but also found them in the blood of a diabetic who had no fever, but was thought to have latent malarious infection. In all four cases these disappeared under quinine. Subsequent observations showed that the parasitic nature of these was only apparent. Many such are figured in books on histology (Frey, Ranvier, &c.), and are well-known

* *Loc. cit.*

† *Kurtze Bemerkung zur ætiologie der Malarie.* Virch. Arch., 1880.

‡ *Einige Beobachtungen über den Bacillus Malariæ. Cl. Me. Woch.*, 48.

to depend on the mode of preparation and chiefly on the action of heat.

It is reasonable to hold, as already noted by Tommasi-Crudeli, that many of the forms described in the blood of malarious persons are due to filaments of this kind issuing from the blood corpuscles, and liable to impose on the observer as bacillary forms.

The small forms described by Marchaud and Ziehl remain to be more fully studied, especially as they have never been able to stain and preserve preparations of such.

The filaments described by Laveran and Richard, representing, according to the former, the parasite in its perfect state, originate in the way just mentioned. We have found in fresh blood that when the degeneration of the red globule is almost complete, and the normal protoplasm only remains as a delicate zone, very movable filaments separate from it, which after a time become free. These are never stained with aniline dyes, and however careful our examination we never discovered coloured prolongations in the degenerate and pigmented globules. The semi-lunar forms of Laveran originate when only half a red globule is converted into a pigmented semi-lunar body, whilst the other half is decolorized and only retains its subtile outline. Leaving these pseudo-organisms we come to the last part of our observations this year.

We have seen how in certain cases, from the cause described, an enormous quantity of red globules perish. We must add that in the same patients in whom this destruction of red cells occurs are found *red nucleated globules, larger red globules (macrocytes), and red globules which are coloured differently from ordinary ones.*

We cite the following case in point:—

C. L., ætat 19, of Rome, carter, entered the hospital September 10th. He had never previously suffered from malarious fevers. From September 1st to 8th he had attacks of quotidian intermittent. From the 8th he said the fever had never left him. A few hours after admission the fever was very high (41°), skin earthy yellow, spleen swollen and tender, sensorium blunted. Examination of the blood shows many red globules altered as described, pigment white ones. Quinine injected. Next morning temperature 38°·5, evening 40°. New injection of quinine.

Blood examined with same result. Subcontinued form lasted until the 15th, when the evening temperature was 37°·7. Blood examined with same result until the 13th, when there began to appear *nucleated red globules, very voluminous red globules*, with a diameter nearly twice that of a normal red globule. The number of the white cells and of the piastrine was clearly increased. Improvement continued until he left the hospital cured on the 28th, and whilst the altered and pigmented red globules and pigmented white cells went on diminishing, the nucleated red globules increased, and the macrocytes in their turn also became few in number. The convalescence was rapid. The appetite become voracious. The vital powers, which were reduced, returned quickly.

The red nucleated globules and macrocytes in many cases of acute malarious infection are recognized in the fresh and in the dried and stained preparations. In those stained with methylin blue the nucleated red globules exhibit their protoplasm greenish blue in colour, the outline and corpuscles of the nucleus dark blue. The form varied; protoplasm sometimes abundant, sometimes scarce. Usually they have one but sometimes two nuclei, one in process of division or germination.

This nucleus often seems issuing from the protoplasm. The macrocytes, which in the fresh state are very pale, are coloured by methylin blue less intensely greenish blue than the nucleated red cells.

The "piastrine" are coloured slightly blue, and appear alone or in groups, almost always with sharp outlines.

What is the meaning of the presence of all these elements, and especially of the nucleated red globules?

It is known that the nucleated red globules are not normally found in the circulation in extranterine life except in the first days of the same, but are found sufficiently frequently in the grave essential and symptomatic anæmias, in more or less considerable number, whilst they are very abundant in the bone marrow, and even spleen.* Erlich† drying and staining blood preparations found them easily. Hitherto, however, they have

* In a case of grave anæmia in a young person Marchiafava found numerous nucleated red globules (10—12 in each preparation), and after death a large number in the spleen and bone marrow.

† *Berlin Klin. Woch., 1881.*

not been described in acute malarious infection. Their presence, as well in the later stages of the disease as during convalescence, has without doubt a connexion with the destruction of red globules, and is a sure indication of the greater energy of function of the hæmopoietic organs rendered necessary by the destruction of red globules in such large numbers.* As to the macrocytes and red globules coloured differently to the ordinary ones, they are evidently young red globules which have recently lost their nucleus, and this coincides with what has been observed by Bizzozero and Salvioli† on the blood of animals rendered anæmic by frequent bleedings.

We wished by experiments, in which destructions of red blood globules had been artificially produced, to institute a comparison with those cases in which this was due to malarious disease. We selected pyrogallic acid as the agent for this destruction, as shown to be such by the experiments of Neisser, Afanassiew, &c.

1ST EXPERIMENT.—White dog of medium size.

3. X. 83. 11 A.M., subcutaneously injected with gr. 0·5 of pyrogallic acid dissolved in 10 cc. of distilled water. 7 P.M., animal not at all ill.

4. At 11 A.M., injected gr. 1 pyrogallic acid in 10 cc. distilled water. 1 P.M., blood examined. Numerous red globules in process of destruction, or reduced to simple decolorized bodies. Masses of hæmoglobin of varied size, staining with *eosin*. Animal collapsed. Urine olive green. No jaundice. Died at 5.30 P.M.

Autopsy.—All the viscera of a leaden grey colour; spleen swollen and black; liver dark blue; gall bladder surcharged with fluid bile; kidney same colour; bladder empty; bone marrow chocolate; black coagula in heart and blood vessels. Blood examined, shows red globules undergoing destruction; numerous red globules perfectly decolorized; granules and masses of pigment, and some nucleated red globules. Splenic pulp and bone medulla, especially the latter, show numerous nucleated red globules.

* Professor Rossoni has often observed with the spectrum of Vierordt the gradual diminution of hæmoglobin in the blood in relation to the quantity of altered red globules, and its gradual daily increase in convalescence along with the appearance of numerous nucleated red globules in the blood.

† *Ricerche sperimentali sulla Ematopoesi splenica*. Archiv. Bizzozero, vol. iv. n. 2.

2ND EXPERIMENT.—Black dog, middle size.

5. X. 83. 10 A.M., subcutaneous injection of gr. 0·5 pyrogallic acid in 10 cc. of distilled water. 1 P.M., examination of blood negative.

6. 7 P M., examination of blood. A few red globules undergoing destruction.

7. 10 A.M., injection as above. 11 A.M., blood examined. Many red globules in process of destruction; a few nucleated red cells. Animal much depressed. Urine dark olive. Microscopic examination of urine shows casts of hæmoglobin. No jaundice.

8. 11 A.M., blood examined. Small number of red globules in process of destruction; nucleated red globules. Animal gradually recovered up to 15th, when no altered red globules nor nucleated red globules were found.

3RD EXPERIMENT.—Small black dog.

11. X. 83. 12 noon, subcutaneous injection of gr. 1 pyrogallic acid in 10 cc. of distilled water.

12. 8 A.M., dog collapsed—somnolent. Does not eat. Urine olive green; vomits yellowish-green liquid streaked with blood; sclerotic, not jaundiced. Blood examined; numerous red globules in course of destruction; cells decolorized; masses of hæmoglobin. 5 P.M., same state.

13. Blood examined. Same as above. Animal continues sunken—somnolent. Does not eat.

14. Examination of blood fresh and after staining. Very few nucleated red globules; red globules very much larger than normal. Dog in same state.

15. Examination as above. Animal collapsed.

16. 9 A.M., found dead.

Autopsy.—All the organs leaden grey colour. In every dried and stained preparation of blood of right heart numerous red globules in course of destruction; normal red globules; red globules larger, and even double normal diameter; red globules normal in size, stained greenish-blue; a few nucleated red globules (4—5 per preparation); numerous white globules, less or more nucleated with protoplasm, granular and hyaline; endothelial cells. In the splenic pulp numerous white cells, containing coloured fragments of red blood globules and nucleated red globules. The bone marrow, microscopically of dark red

colour, contained white cells inclosing fragments of red globules; proper cells of marrow; cells with budding necleus, and nucleated red globules in greater quantity than in the spleen and blood of the heart. The nucleated red globules both in the circulating blood and in the spleen and marrow showed more distinctly by staining with methylin blue the preparation dried by heat.*

From these experiments it results, therefore, that by producing destruction of red globules, after a very short time are found in the blood nucleated red globules; red globules of more than normal size; globules staining differently to ordinary ones—elements all met with more abundantly in the spleen and bone marrow after death. That the presence of such nucleated red globules is derived from augmented hæmopoietic activity, and expresses a true regenerative compensation, is beyond doubt. The same explanation is given by all who have of late studied the physio-pathology of the blood.

This view is strongly confirmed by our observations, because in some cases of malaria infection one is almost able to see before his eyes the two processes of destruction and regeneration of red globules.

Thus by examining the blood of a subcontinued fever patient, from the day of his entrance into hospital to that on which he left it cured, we see that three or four days after the destruction was arrested nucleated red globules began to appear, increased rapidly in number, and once more diminished as convalescence became established.

It is reasonable therefore to hold that the passage into the circulation of nucleated red globules happens, because the formation of red globules in the hæmopoietic organs is so active and hurried that the red globules, in course of formation, are forced into the circulation before they have lost their nucleus.

Although these researches of ours have not yet fully attained their aim, we believe we have helped to make better known the change produced in the blood in malaria, and to clear up the origin of melanæmia. It still remains to determine the nature of the specific agent, to which these changes are due, and to this end further researches will be directed. Finally, it will be easy to judge if any advantage is likely to accrue from them to clinical medicine.

* *Bizzozero*, Neumann, Salvioli, Foà, Pellacani, Orth, Lillen, &c.

It has been already said that they are not always found in slight, and are also absent in some grave forms, clinically considered to be malarious, therefore their absence does not exclude malarious infection, while their presence does not render it indisputable; and, furthermore, it has not occurred to us to find them in other infections (typhoid fever, cerebro-spinal meningitis, measles, pneumonia), in which we have had an opportunity of examining the blood.

A NEW CONTRIBUTION

TO THE

HISTORY AND ETIOLOGY

OF

SPONDYL-OLISTHESIS.

BY

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OF WARSAW.

TRANSLATED BY

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TRANSLATOR'S INTRODUCTORY NOTE.

Since Kilian, in 1858, first drew the attention of obstetricians to the spondyl-olisthetic pelvis through the specimen known as the Prague pelvis, no new light had been thrown upon the condition until Neugebauer, in 1884, propounded his views in the *Annales de Gynécologie*. Until Neugebauer had examined and described the seventeen pelves recognised as spondyl-olisthetic up to that date, the views of Rokitanski and Kilian, that the lesion originated in caries of the vertebra, were generally accepted. Neugebauer, however, demonstrated by his specimens at the Obstetrical Society in 1884 that in many cases the deformity arose from some breach of continuity, either traumatic or congenital, in the neural arch. A committee was appointed by the Obstetrical Society, consisting of Dr. Robert Barnes, Messrs. William Adams, Alban Doran, and Noble Smith. These gentlemen, after having examined the specimens and consulted thereon, reported that they agreed with Dr. Neugebauer in his views, and confirmed the accuracy of his conclusions. It is now generally accepted that this deformity in the majority of cases results from a solution of continuity across the neural arch of the fifth lumbar vertebra between its superior and inferior processes on either side. This theory is in opposition to the views formerly held, namely, that the deformity occurred from caries, rickets, osteomalacia, tuberculosis, or hydrorachis. The solution of continuity of the neural arch may, according to Neugebauer, be congenital or acquired. Neugebauer suggests that pathologists should carefully examine the pelvis in all fatal cases of injury from falling. He believes that if this is done, commencing or advanced spondyl-olisthesis will be occasionally discovered.

FANCOURT BARNES.

A NEW CONTRIBUTION

TO THE

HISTORY AND ETIOLOGY OF SPONDYL-OLISTHESIS.

ALTHOUGH the history of spondyl-olisthesis has quite recently been enriched by the interesting work of Swedelin in the last number of the *Archives of Gynækology*, I nevertheless am induced to publish separately some fresh clinical observations made by me since that time, as they are valuable from several points of view. Some time ago 17 cases of lumbo-sacral spondyl-olisthesis as pathological specimens and only 16 cases seen clinically were published and made known to a large circle of the profession. It now appears that two accounts published in 1875 were overlooked in the making the list of the literature of the subject, as they were accessible only to a limited number of readers: one of these was a case of spondyl-olisthetic pelvis seen during labour at Christiana, and published in the transactions of the medical society of that place; the other was a dissertation published at Friburg in 1875, in which two other cases were described by Egger. The number of clinical observations was thus increased to 19, to which I will now add 6 more; of these one was seen by Hegar in Friburg, one by Freund in Strasburg, while one at Strasburg, another at Paris, and two more at Berlin have lately come under my own observation. The total number of clinical cases, including one of Zweifel's at Erlangen yet unpublished, would therefore amount to 26.*

* In all, therefore, 43 cases of spondyl-olisthetic pelvis (including one clinical case in a man) were known up to January 1884, viz.:—

(*a*) 17 anatomical preparations: 2 each at Prague, Vienna, and Würtzburg; 1 each at Bonn, Breslau, Giessen, Halle, Liège, Moscow, Munich, Paderborn, Paris, Treves, Zurich (in 9 of these cases the subjects had been under clinical observation during life).

(*b*) 26 clinical observations: in Berlin, Friburg, and Strasburg, in each 8 cases; in

Before describing my own observations at Strasburg, Paris, and Berlin, I will give a short report of the other cases mentioned.

Clinical Observation in Christiana.

This case is published in the *Forhandlinger i det norske medicinske Selskab i* 1874, Christiana, 1875; contained in the journal *Norske Magazin for Lagevidenskab, Udgivet af det medicinsk Selskab i Christiana Tredie raekke.* Redigirt af Jacob Heiberg. Tjerde Bind, Christiana, 1874 (?).

Unfortunately I was unable, in spite of much trouble, to obtain the journal in question, and must therefore confine myself to the transcription of the written account brought to me from Christiana by my father on the occasion of a summer trip to Norway.

On pp. 173—200, 189—200 of the journal mentioned in the report of the meeting of the Society under the Presidency of Dr. Schönberg, on the 23rd September, 1874, the following communication is to be found: Dr. Vedeler, assistant to Professor Faye, describes a case of spondyl-olisthetic pelvis seen in his clinic in 1874. The woman, aged 28, was admitted into the hospital pregnant for the eleventh time, and in the absence of Professor Faye, and was delivered by the induction of premature labour by Dr. Vedeler and Dr. Kaiser. In the report of the meeting on the 7th October, 1874, pp. 200—213, 202—204,

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Dresden, Halle, and Prague, in each 2 cases; and 1 case in each of the following towns: Basle, Berne, Christiana, Coblenz, Erlangen, San Francisco, Leipsic, London, Petersburg, Stuttgart, and Paris.

Lastly, I learn from Professor Nicoladoni that there is an anatomical preparation at Innsbruck; and Professor Mayer, of Friburg, informs me that he has such a pelvis in his collection. Professor Mayer could not, however, find it during my stay in Friburg, as he was just in the act of occupying a newly built institution, and a large number of the preparations were still packed up on account of their removal.

The French obstetrician, Charpentier, in his comprehensive text-book of midwifery, which was published in two volumes only a few months ago, has given the total of spondyl-olisthetic, including spondylizematic pelves, as only 29 (*Traité pratique des Accouchements.* Paris, 1883, Tome ii., p. 110), although he so freely cites the foreign literature of the subject. In the section relating to this affection no reference is made to the more recent studies on the etiology of spondyl-olisthesis, even the clinical aspect of this anomaly is lightly mentioned, and the historical information from the literature is not always accurate. M. Charpentier had at the time, as he informs me, no knowledge of the more recent works on the subject of spondyl-olisthesis, and this defect will be remedied in the next edition of his work.

it is stated: Professor Schönberg said in reference to Vedeler's communication on spondyl-olisthesis that he had himself examined the woman during labour, and must confirm the diagnosis.

In a later volume of the same journal, in the proceedings of 1876 (Christiana, 1877), it is stated in the report of the meeting on March 8th, 1876, pp. 31—48, 33—41, L. Faye (p. 33) gives a description of the twelfth labour of the same woman in whom in November, 1875, he had, in conjunction with his father, F. C. Faye, induced premature labour, the child being still-born and the mother recovering. Faye declares the pelvis not to be spendyl-olisthetic, and quotes a remark made at the time by Professor Faye, to the effect that he also thought the dislocation of the vertebral column to be the result of inflammatory softening. He says further, on page 41, "Vedeler holds to his diagnosis of spondyl-olisthesis"; and finally, on pp. 41, 42, it is stated, "Schönberg points out that the fifth lumbar vertebra was dislocated downwards, and that there actually was a spondyl-olisthesis." The extracts here given are not sufficient to explain clearly the exact abnormality existing in this pelvis, and it would be desirable to get further details from Christiana.

The next two cases, seen by Hegar before 1875, are described by Egger,* but as his dissertation had only a limited circulation, I will, with the permission of Herr Hegar, give an extract from it here.

After a general and historical introduction a description is given of the

First Clinical Case of Spondyl-olisthesis at Friburg.

The patient was a married primipara, aged 28. Her father died from consumption in his 62nd year; her mother died in her 45th year, but no history of her mother's health or cause of her death could be obtained. Two sisters are living, and healthy. During early childhood she had no illness, but she had an attack of pituitary fever when she was four years old. She learnt to walk at the end of her first year; no signs of rickets. Her mother died when she was five years old, and she was given up to the care of strangers, and had to help in field labour,

* Siegfried Egger, *Das Spondyl-olisthetische Becken, Mang. Diss.* Friburg, 1875.

carry heavy loads on her head, and undertake work for which from her age and bodily strength she was still unfit.

In 1861, in her 14th year, while she was descending a small hill, carrying a heavy water-bucket on her head, she unfortunately tumbled, and falling backwards on to her sacral region the water-bucket fell on her belly. She was not able to get up again from the ground, and had to be carried home to bed. Severe pains came on in the sacral region, and about the hypogastrium, and it was only after three months had passed that she was able to make careful attempts to walk, with the aid of a stick, which she had to use for three months longer. Her body was passably bent, and from time to time the sacral pains recurred when she walked. By degrees she was able to walk upright and unaided, and from that time also the sacral pains disappeared. She does not believe that she has grown any shorter since the accident.

Menstruation came on in her 18th year, on the first and second occasions with some difficulties; it was regular, but was always preceded by slight sacral pain, which disappeared during the three days of the discharge. These pains did not interfere with her work as a domestic servant. In 1868, while lifting a heavy weight, she was suddenly seized with severe pain in the back, and was obliged to seek relief in the hospital, from which she was discharged cured, after stopping there only fourteen days. From that time she felt perfectly well; was married in 1874, and on the 10th of November of the same year after a normal pregnancy her labour commenced. On the same evening, the labour pains not having been particularly strong, the waters broke and the cord prolapsed. Next day, after version had been attempted, a dead child was delivered by the forceps. The hæmorrhage was moderate, and the placenta came away of itself.

Puerperal endometritis coming on, she remained in bed for four weeks, but was then compelled by circumstances to leave it, and immediately she was attacked with the most violent pains in the right hypogastrium. A swelling the size of an egg was found in the right parametrium, which gradually diminished under the use of moist applications, and was on a subsequent examination found to be the size of a nut. She had then no more pain, but only a feeling of tension in the hypogastrium; besides

which she was feverish, felt very weak, and as she could not receive proper attention at home, she sought assistance in the Gynæcological Hospital. The patient is 165 cm. in height, well developed as to bony structure, and moderately fat. Cheeks and mucous membranes are pale; stands and walks upright. There is a slight lordotic sinking in of the lumbar vertebra, which is more noticeable when the patient lies prone. There is no indication of hydro-rachis in the sacrum or skin of the pelvis. The spinal column can be easily felt through the abdominal walls with quite moderate pressure. The symphysis is very high, somewhat perpendicular, the inclination of the pelvis is slight, and the genitals are directed forwards. The legs are quite straight, and there are no signs of rickets in the costal cartilages. The vagina is fairly capacious; the vaginal portion lies somewhat posterior to the vertebral line; the corpus uteri enlarged, but in fair position. Both body and neck of the uterus are slightly movable. The linea terminalis is considerably elongated in its anterior segment; the pubic arch narrow. The bifurcation of the aorta cannot be felt, nor any large pulsating vessel corresponding to one of the iliac arteries. Projecting from the anterior surface of the sacrum for about the thickness of a vertebra, immediately behind the vaginal portion, is a hard prominence, which is apparently the last lumbar vertebra, this having slipped down a little to the right, so that the left half of the pelvic inlet is wider than the right. The projecting angle of dislocation is exceptionally distinct.

In the rectum one can feel the projecting dislocated vertebra as well as the projecting angle of dislocation, and also both sacro-uterine ligaments very much thickened and unyielding. The following measurements of the pelvis should be recorded here:—

Diameter between the anterior superior spines	27·0
„ „ crests of the ilia	31·0
Distance between the trochanters	34·0
Diameter of Baudeloque	18·5
External oblique diameter, left	23·0
„ „ right	24·0
Distance between the tubers of the ischia	10·0
Distance from the lower margin of the pubic arch to the angle of dislocation	12·0
Distance from the lower margin of the pubic arch to the most prominent point of the lumbar vertebra within each	9·0

The anamnesis with the present condition completely justify the diagnosis of spondyl-olisthesis.

In conclusion, Egger disposes of certain objections as to the existence of rickets, exostoses of the pelvis, &c., &c.

Second clinical case at Friburg (*l. c.* pp. 16, 23), Salome Haug, of Eichstellen, aged 33, single, a primipara. Her father died at the age of 67 from an attack of apoplexy. Her mother is alive and in good health, and she has eight brothers and sisters in the enjoyment of the best health; she herself was never ill when young. She learnt to walk even in her first year, and did not again leave off doing so. At the age of 14 she went into service and had to work hard.

Menstruation was normal from her 16th year. In her 19th year she was suddenly attacked by severe pains in the sacral region, without any definite cause, and noticed during her illness an increasing weakness in her lower extremities. Under careful treatment this condition improved so that she was again able to take service in an easier place, and only suffered off and on from some sacral pain; one day, however (1870), while she was lifting a pail of water she was seized suddenly with violent pain in the sacral region, and at the same time noticed a cracking noise in that locality. She broke down, and had to keep her bed for a whole three months. At every attempt to stand the pains were at first very severe, but became less so as time went on, and she gradually regained her power of standing and moving about; she remarked, however, that she was shorter than before her illness. Her poverty compelled her to go into service again, and she had very good health until May, 1872, when she conceived. The course of her pregnancy was on the whole normal; she only suffered at times from sacral pain, and was very quickly fatigued if she walked about. She went home and prepared for her lying-in, and labour pain, began on 28th January, 1873. The presentation was transverse; and on the morning of the 29th January the medical attendant made several attempts to turn under profound chloroform narcosis, unfortunately in vain. Herr Hegar was consequently called in.

He did not arrive at the place, which was at some distance, till five o'clock in the evening. The right arm protruded outside the vulva, and the uterus was most firmly contracted round the child lying across the pelvis. Several attempts at turning were

made, but in vain. The neck of the child was within easy reach, and decapitation was therefore carried out by means of long scissors. The operation was comparatively easy, as was also the delivery of the trunk depending on it. The principal difficulty, however, remained in the delivery of the head left behind in the uterus, and this difficulty was increased by the circumstance that in the decapitation the first cervical vertebra had been left attached to the head, and as a consequence the foramen magnum could not be made use of. The next thing to be done was to steady the head, and for this purpose a hook was passed into the mouth on which traction was made. The assistant, however, pulled too hard on the hook and broke the lower jaw. As the best point to lay hold of for fixing the head was lost, it was while continually rolling about laid hold of by a sharp hook carried through the roof of the orbit and the cephalotribe applied, the assistant at the same time affording support to the head by external pressure.

This attempt itself was not successful. The cephalotribe had only seized a small segment of the head and began to slip off, just as the hook lost its hold in the same way as in the attempt to fix the head by the mouth. A similar failure resulted from the same process in the other orbit; and as all means of delivering the head hitherto attempted had failed, Herr Hegar tried to reach the posterior side of the head by carrying his hand up along the sacrum, and he was able to get at a point in the squamous suture which admitted of the introduction of the scissors-shaped perforator. This passed upwards along squamous portion of the temporal bone, yet its application to the squamous suture was very difficult because the squamous part overrid the edge of the parietal bone, bevelled off in the opposite direction, and slipped away over it. Only after much trouble did the instrument pass through the suture, and at first it slipped upwards between the inner side of the skull and the dura mater, because its handle could not be sufficiently depressed. At last the membranes were perforated and the cranioclast applied; the extraction of the head was then easily accomplished. The placenta followed spontaneously.

The patient lay sick for eight weeks, feeling extremely weak, with high fever and profuse perspirations. The lochial discharge was moderate, and there were occasional pains in the abdomen.

During these eight weeks the urine was passed involuntarily; the menses had not reappeared since the labour. In this state she was admitted into the Friburg Gynækological Clinique, where the incontinence of urine, which was due to paralysis of the sphincter vesicæ, was cured, and after three months' stay in the hospital she left it fairly recovered. She still suffered from slight occasional pain in the sacral region, and had some difficulty in standing and walking, feeling quite well only in the horizontal posture.

Salome Haug was 157 cm. in height, of rather powerful, bony development, fairly covered with muscular and adipose tissue. Her extremities were not crooked; her thorax, not unduly arched, was smooth without any rachitic change. The cervical and dorsal vertebræ were regular, but there was a well-marked lordotic depression in the lumbar spine. The sacrum only moderately steep. In the lumbo-sacral region no hiatus could be felt, nor could any scar or puckering be found which would have indicated the presence of a congenital hydrorachis. The symphysis pubis was very high up. On pressure on the abdomen the lumbar vertebral column could be very easily felt, and appeared to be displaced forwards. A plumb line held against the dorsal vertebra falls into the base of the sacrum, and the distance from the deepest point of the lumbar lordosis measures 2 cm. to this line, while the distance from the same point to a line joining the most prominent point in the thoracic vertebra to the most prominent point in the sacrum, is 4·5 cm. The plumb line in the axilla falls in front of the trochanter major, and if suspended in the line of the trochanter lies posterior to the scapula. Haug, who when young used to walk bolt upright, now walks slowly, unsteadily, and with difficulty, like one with sacral paralysis. Her feet are turned rather inwards, and in standing and walking the upper part of her body is bent forwards and the knees are decidedly bent.

On examination the vagina was found moderately capacious and short, the arches of the anterior half of the pelvis convergent, and more so on the left side than on the right. The vaginal portion was short, and in normal position; from the right commissure there was a cicatricial band running to the vaginal roof. The body of the uterus was retroflexed. On the posterior wall of the pelvis there was a hard blunt projection at the level of

the first sacral vertebra, which was, however, not very distinct. The bifurcation of the aorta could not be reached, nor could any large pulsating vessel corresponding to the right or left iliac artery be felt.

Examination per rectum, though the different parts of the pelvis were easily felt, threw no fresh light on the spondyl-olisthesis; the blunt projection in the vertebral column lay directly in the middle, inclined neither to the right or left.

The following pelvic measurements should be mentioned here:—

Diameter between the anterior superior spines	25·0
„ „ crests of the ilia	28·5
„ „ trochanters	31·5
Baudeloque's diameter	19·0
External oblique diameter, right	21·0
„ „ left	22·5
Distance between the tubers of the ischium	9·5
Diameter of cavity of the pelvis	11·0
From the lower margin of the pubic arch to an angle in the lumbar vertebræ	10·0

The information derived from the history of the case, especially the fact that the patient used to walk quite straight, and that the change described afterwards took place in the way she held herself and walked, in addition to the fact that subsequent to pains in the sacral region, the patient while lifting up a heavy weight felt a distinct snap in that part of her body, the pains which followed, and the three months inability to stand or walk, all indicate a pelvic spondyl-olisthesis existing in her case.

Egger adds to the description of these two cases some remarks on the various modes of standing and walking of different women affected with spondyl-olisthetic pelvis, and says on page 23, "In the carriage and deportment of persons with pelvic spondyl-olisthesis nothing typically characteristic has been observed," and he endeavours to justify this statement by a collection of all the information published on the subject. Now, I believe that the analysis I have published in my various works, of the carriage of body, the mode of progression, and foot-prints, in the different stages of spondyl-olisthesis, completely disproves this view of Egger's. As for the rest I would refer to the description given further on of my Strasburg case, in which my presumptive diagnosis actually depended on the typical character of the mode of progression. On the etiology of these cases Egger says on pp. 29, 30, "It has already been mentioned that both these

patients had when young suffered from inflammatory processes in the sacral region, and these chronic processes probably extended to the joint between the inferior oblique process of the last lumbar and the articular process of the first sacral vertebra. In the first case (that of Engler) a fall while descending a small hill, in the second case (that of Haug) was the immediate cause of rupture of the ligaments and laxation of the oblique processes which had been the seat of that chronic inflammation, and thereby was the signal for the slipping in of the last lumbar vertebra."

He concludes on page 30 as follows: "Herr Hegar assures me that the delivery of Salome Haug was the most difficult he had met with in his extensive practice, and in his opinion the difficulty in the delivery of the head was considerably increased by the previous decapitation, whereby the possibility of fixation of the head was lost. In such cases eventration, or even the bisection of the trunk, would be preferable."

The diagnosis appears from the conditions as reported to have been correct in each case. I cannot, however, agree with Egger that the deformity was caused by the inflammatory processes in the sacral region which existed in earlier years, but would rather in each case attribute it as directly due to an injury, a fracture. In the second case a congenital spondylolysis interarticularis of the arch of the fifth lumbar vertebra may be accepted as a predisposing cause of the development of the deformity. Yet this idea seems rather at variance with (or somewhat hardy in view of) the principles I have elsewhere advanced on the development of olisthesis in early life, before the occurrence of pregnancy, &c., &c. How easily an accidental injury of this kind may be overlooked, is proved by those cases in which, though the occurrence of anything of the sort is denied, on the first investigation of the case it is nevertheless subsequently ascertained that such an injury did take place (*vide Archiv für Gynäkologie*, Bd. xix., Hft. 3, § 463). However, as I have completely proved elsewhere, all the results of anatomical and clinical study of the etiology of spondyl-olisthesis certainly oblige us in most cases to look on an injury as the cause, and in any case this second Friburg case is not singular as regards its etiology, for the same statements have been made in several others as to the time and manner of the commencement of the deformation—"Sudden sacral pain, without any alleged inducing cause."

It would not be easy to obtain a supplemental and more exact anamnesis in these cases. Salome Haug, for example, is now dead, and even if in these exceptional cases there is no history of any previous injury, we are nevertheless obliged, by the more exact details given in the vast majority of recent cases, to believe in the previous occurrence of an injury, or fall back on the existence of a congenital spondylolysis. It might also be said that in this second Friburg case, that the first attack of sacral pain and difficulty in moving about in the patient's 19th year must be attributed to some cause quite independent of the spondyl-olisthesis, and that the latter was only brought on by lifting a bucket of water in her 29th year, and therefore ten years later. To this I would answer that a better explanation for those symptoms which occurred in the patient's 19th year than a commencing olisthesis is, must at least be looked for. And moreover it is definitely stated that from the time of the first sudden attack of sacral troubles in her 19th, up to that of the injury in her 29th year, Salome Haug continually suffered off and on from sacral pain, and was obliged to look for an easier place of service. There is, therefore, in all probability a distinct connection between her sickness when 19 years old and that in her 29th year. Finally, from the pelvic measurements taken in 1873, from the account of the delivery, and also from the fact that Salome Haug's attitude in moving about was later on one bending over forwards, it appears that the spondyl-olisthesis was one of a considerable degree. Now the development of olisthesis is most gradual, according to our present clinical experience it is a question of years, and it is therefore far more natural to suppose that the process of olisthesis had as a matter of fact begun when the patient was 19 years old, and that the injury ten years afterwards, when she heard a snap in the sacral region, was important as making matters much worse. Indeed I would suppose that this injury in the 29th year corresponded with the moment in which the process passed out of the stage of spondyl-olisthesis of Lambl into the stage of spondyloptosis, in which a secondary infraction of the interarticular portions of the arch of the fifth lumbar vertebra took place, and that to this infraction is to be ascribed the sensation of the snap in the sacral region. I have elsewhere pointed out how under pressure and tension the arch of the fifth lumbar vertebra becomes elongated to the greatest

possible extent, and bent over forwards and downwards, and have theoretically deduced the occurrence of this secondary infraction, and am rejoiced to find this very interesting point in the anamuesis of Salome Haug supporting my theoretical deduction of secondary infraction of the vertebral arch, to avoid the repetition of which I refer to my earlier works on the etiology of spondyl-olisthesis. I would therefore consider the injury that Salome Haug suffered in her 29th year as a consequence of the maximum elongation gradually attained under tension of the arch of the fifth lumbar vertebra, on the occasion of a sudden increase of the body weight by taking up a burden, and I would date the origin of the olisthesis back to her 19th year, ascribing it principally to an injury sustained before that time, though not recorded in the anamuesis, and in a less degree to a congenital spondylolysis articularis of the arch of the fifth lumbar vertebra. That this latter as a matter of fact led to a spondyl-olisthesis is proved by the pelvis of the Hottentot Venus, the Prague-Wurzburg pelvis, that at Bonn, the second Wurzburg pelvis, and two cases of olisthesis of the body of the last lumbar vertebra but one, which I have myself described, and other cases also. In most such cases of congenital interarticular spondylolysis of the vertebra, which are indeed often enough accidentally revealed on a post-mortem examination, the ligaments which hold together the disunited portions of the vertebral arch are still powerful enough to keep the parts in position under pressure, and to prevent the slipping downwards and forwards, the displacement, the olisthesis of the anterior half of the vertebra, which is directly subjected to the body weight, and especially so if pregnancy does not occur.

Finally, this sudden and abrupt transition out of the stage of olisthesis of Lambl into that of complete spondyloptosis, accompanied by an appreciable "snap" in the patient's 29th year, induces me to believe that there was in this case a secondary infraction, which of course excludes the pre-existence of a spondylolysis.

The question of the genesis of this second Friburg case cannot be definitely settled from its history. But the experiences of the past two years have shown that spondyl-olisthesis lumbosacralis is however by no means such a very rare affection, and we may hope in future, by the greatest care in noting the anamuesis,

to obtain in every case decisive evidence as to whether the affection owes its origin to a fracture or to a congenital spondylolisthesis (? olysis) *sic*.

Nothing new is added to our knowledge of the symptoms of the disease by the histories of these two cases, though very many of the facts stated so completely correspond with or are supplemented by those recorded in other cases of the same sort, that I regret not having sooner met with this Friburg dissertation. The second case is particularly interesting obstetrically, showing as it does that though the character of the pelvis had not yet become that of one outwardly kyphotic in the extreme, the shortening of the conjugate diameter of the pelvic inlet was so considerable, and the delivery so exceptionally difficult, that Herr Hegar pronounced it to be more so than any he had met with in the many years of his extensive practice. In particular the distance between the great trochanters of the femora (31·5) still remained 3 cm. greater than the distance between the crests of the ilia, an excess still so large as to show that the rotation of the hip bones outwards, and proportionately therefore the rotation of the sacrum backwards, was as yet by no means considerable, and nevertheless the delivery by operation was exceptionally difficult. It is stated that the conjugata diagonalis spuria, measured from the pubic arch to an angle in the lumbar vertebræ, was 10·0 cm., but the particular angle or vertebra is not mentioned. It may be presumed that the smallest conjugate measurement of this pelvis lay above* the proper plane of the pelvic inlet, and indeed so high up that its dimension could hardly if at all be ascertained per vaginam, and could only be approximately estimated from measurements taken above it through the abdominal walls.

However that may be, there is exceptional interest clinically in the case of Salome Haug, because it proves that the degree of contraction of the pelvis in a conjugate direction, in and superior to the plane of the pelvic inlet, which is most to be thought of in delivery, cannot be estimated with absolute exactitude from the other dimensions of the pelvis. For example, in Minna Berndt (first Dresden case, 1882), in whom the distance

* This is also probable, from the fact that in Salome Haug, as also in Katharina Lommins, Theresa Barta, and Henriette Rudolph, when moving about the attitude of the trunk was bent over forwards, the inclination of the pelvis being more or less diminished.

between the crests of ilia was 27·5 cm., and that between the trochanters 27 cm., and therefore only 0·5 cm. less, while the distance between the tubers of the ischia was 6·0 cm., and therefore the external kyphotic character of her pelvis was far more developed, the natural forces were sufficient to cause the advance of the fœtal head as far as the pelvic outlet, and the pregnancy terminated normally in the birth of a living child, while in other cases, in which the external kyphotic character of the pelvis has been far less developed, the delivery has been fatal to mother or child, or to both. I cannot here digress to enter on this most interesting obstetric question, which I must leave for a separate work. I would only insist that the danger attending a delivery cannot be estimated from the external dimensions of the pelvis by themselves, nor is obstetric aid to be doled out by centimetres. One may indeed determine the amount of contraction in the outlet and cavity, and in favourable cases where the head presents and is still movable even that of the anatomical inlet, of the pelvis, but when labour is going on we cannot make an exact estimate of the contraction in the median plane above the plane of the anatomical inlet to the pelvis, the very seat in many cases of the greatest obstacle to delivery, of the greatest contraction. That not only during labour itself, but even when pregnancy is not far advanced, it may be very difficult under certain circumstances to feel the lumbar vertebral column in the plane of the anatomical pelvic inlet, or even somewhat lower down, was proved in the first Dresden case, in which at his first independent examination Winckel was unable to reach the lumbar column or angle of dislocation per vaginam, and only concurred with my diagnosis after he had again examined the woman lying on her side. Indeed in one case in practice, in which it was stated that on account of the fœtal parts presenting, the lumbar column could not be distinctly made out per vaginam, the obstetrician in attendance quite disregarding on that account the angle of dislocation, made his diagnosis of spondyl-olisthesis only on the external kyphotic form of the pelvis, the attitude of the body, &c., &c., combined with the absence of any kyphotic lumbo-sacral convexity. The place of the greatest contraction, whether in the median plane, or if the case is complicated by scoliosis, in a somewhat extramedian but parallel plane, is *often out of* the reach of digital examination per vaginam or per

rectum, and naturally one cannot on account of the pregnancy even reach the vertebral column through the abdominal walls. One can therefore in such cases do no more than estimate the degree of the inclination of the lumbar column forward compared with the inclination of the pelvis. It is not without reason that the spondyl-olisthetic pelves have been grouped among the pelves obtectæ. The task is to find out up to what distance the lumbar column has bent itself over towards the anterior arch of the pelvis. We have a means of approximately determining this contraction in the degree of lumbo-dorsal lordosis, in the attitude of the body, the amount of sinking of the thorax into the greater pelvis. A spondyl-olisthetic pelvis often enough passes unnoticed during a labour, for out of consideration of the exhaustion of the woman in her travail, the attending practitioner neglects to observe her attitude when standing up, and her gait when moving about (as was, for example, the case in the third Strasburg case to be hereafter described). It is therefore manifestly of particular importance to take at least one opportunity of observing the lying-in woman when standing up, at all events in those cases there is great and unexpected difficulty in delivery, from delay in the engagement of the child in the small pelvis, whether it be a spondyl-olisthetic or any other kyphotic, spondylizematic, rachitic, or osteo-malacic, pelvis obtecta, a *luxation pelvis*, or otherwise. And here also no measurements in centimetres from the upper margin of the pubic symphysis to the fifth, fourth, third, second, or first lumbar spine, nor to the dorsal or cervical spines, can lead to any exact conclusions, but the degree of inclination of the lumbar column to the plane of the pelvic inlet should be at all events approximately determined. One should keep before one's mind that inclination is the chief danger and primary obstacle in the way of labour in the pelvis obtecta, and modify one's conduct of the case according to the degree of this obstacle to delivery.

If once the obstetric inlet of the pelvis is passed, unless complications exist, the outlet is generally reached without special difficulty. Happily in most cases (as for example in both the Dresden cases, and many others) any operations which may still be necessary are undertaken at the pelvic outlet, and far less significance for the integrity of mother and child than those at the inlet of the pelvis.

Third Clinical Case at Friburg.

During a short visit I made to Friburg at the time of the meeting of scientific men (*Naturforscherversammlung*), Herr Hegar informed me that he had recently seen another clinical case of spondyl-olisthesis.

The woman in question, Frau Caroline Schweizer, 41 years old, from Hofsgrund (see the *Poliklinical Journal of the Friburg Clinique for Women*, 1883, i., No. 46), had had seven children and one abortion, and in the spring of this year had come to the Poliklinical Dispensary (*Ambulanz*) on account of some uterine affection. After Herr Hegar had diagnosed a spondyl-olisthetic pelvis, and she had been examined by Herr Wiedon, the assistant physician, also, the woman was requested to come another time in order that the anamuesis and present condition should be accurately taken; from that time, however, up till the present she has not again presented herself, and consequently the detailed description and history of the case are still to be expected in the future..

*Second Strasburg Case.**

I have to thank Herr Freund for the notes of the following case, which he examined two years ago with Herr Bayer, at that time his assistant.

Christine Kuiz, from Eschau, was sent to the Strasburg University Clinique for the Diseases of Women for the closure of a vesico-vaginal fistula. She was operated on on July 14th, and discharged on July 26th.

She had never been sick. Her menstruation, commencing in her 16th year, had been always regular, though rather painful. She had had nine children, of whom three had died, and of these two from protracted labour. All her confinements had been very difficult, in two cases because of cross-birth. There had never been any puerperal disturbances. In the last confinement ten weeks previously, the waters began to come away on Sunday. There were no effective pains till Monday night, and the child, which is still living, was born after excruciating pain on Tuesday evening. Immediately after the delivery the patient

* As the first Strasburg case I count the one described by von Hueter in 1875, as seen in the Clinique there at that time under Gusserow.

began to feel stabbing pains in the right groin and iliac region, which were greatly aggravated when she passed water. There was no other particular symptom, and micturition went on as before. She left her bed as early as the fifth day, and it was not until the eleventh day that she noticed that her water flowed from her vagina, as it has done ever since, though she can now and then pass a little water voluntarily. The catamenia have not returned since her delivery.

She is 150 ct. in height, strongly built as to bone. In the lumbar region there is extreme lordosis, with a most remarkable saddle-shaped sinking in of the loins, which is not altered in any movement she makes. There is an angle in the spinal column, between the sacrum and the lowest lumbar vertebra, the angle opening backwards. From the remarkably small difference between the diameters through the crests and trochanters, the external appearance of the pelvis is extremely kyphotic, being distinctly quadrangular, "like that of a cow." The sacrum sticks out prominently behind just as in a kyphotic pelvis, the rhomboid is pretty large, the nates very thin and remarkably hollow. The posterior superior spines of the ilia are well marked and tolerably symmetrical in position, the posterior S-shaped incurvation of the crest of the hip bones are remarkably abrupt and far apart.

The lines joining the S angles to the posterior superior spines on either side, when produced, intersect in an unusually obtuse angle, the apex of which is about 2·5 cm. above the commencement of the anal fissure. The abdomen is very short and pendulous, and consequently there is a well-marked fold of skin passing in a curve transversely above the symphysis pubis. The position of the navel is very low down, only 8 cm. above the symphysis, and the distance of the latter from the ensiform cartilage is only 20·5 cm.

Pelvic measurements—

Distance between the trochanters	30·01
„ „ the crests of the ilia	29·0
„ „ anterior superior spines	27·0
„ „ posterior „	8·5
„ „ S angles of the curves of the iliac crests	12·0
„ „ tubers of the ischia	8·0
Length of the sacrum	18·0
External conjugate diameter	19·5
Length of the symphysis pubis	6·5
Conjugata diagonalis spuria measured to the lower margin of the fourth lumbar vertebra	10·5

The genitals are situated pretty far forward. The vicarious conjugata vera, as measured externally through the abdominal parietes in narcosis, was 7·5 cm., and as some addition must be made to this for the thin abdominal walls it may be estimated at 8 cm. The pelvic outlet seems somewhat contracted transversely. On an internal examination one is at once struck by the high situation, great thickness, and remarkably upright position of the symphysis pubis, the cartilage of which is unusually large and prominent. The sacrum is very long, and its course from below upwards passes well backwards. At the level of the pelvic inlet the finger is stopped by the anterior surface, now quite horizontal, of the depressed body of the last lumbar vertebra, which rounds itself off backwards on either side, and extends well beyond the linea innominata; from either side of the projecting vertebral body the finger passes into an empty space; one can feel on each side of the prominent lumbar column a pulsating vessel, probably the two common iliac arteries, but the bifurcation of the aorta cannot be reached. The lower margin of the body of the fourth lumbar vertebra, which is within reach, takes the place of the promontory. The right half of the pelvis is in every way somewhat smaller than the left, corresponding with a scoliosis. The upper part of the back is flat, the left shoulder being higher than the right; no sign whatever of rickets.

The involuntary flow of water has caused eczema in the neighbourhood of the genitals. The anterior lip of the cervix uteri is slit up in the middle as if with a knife, and when both parts of the lips are drawn apart, one can see in the cervix, as large as a pea, the mouth of the vesico-vaginal fistula. The patient was operated on on 19th July, but had to be allowed to leave before the healing was complete. The complication of this case by vesico-vaginal fistula, the mode of origin of which can be easily understood, makes it particularly interesting.

The three clinical cases which fell under my own observation during the current year, and a fresh case from Paris, are now to be described.

I came across the first case accidentally while I was acting as assistant in the general dispensary (*poliklinischen Ambulanz*) of the Surgical Clinique of Berlin University.

I must, unfortunately, confine myself to the following short

registration of the case, as no complete notes or drawings are at my command.

*Second Berlin Case.**

Mrs. Auguste H., aged 52, the wife of a mechanic from the neighbourhood of Brandenburg, came in the spring of 1883 to the general surgical dispensary on account of a painful ulcer on the nose. Herr Sonnenburg, under whose direction the Policlinique was at that time, diagnosed a carcinoma, and immediately removed the neoplasm by operation. The appearance of the woman struck me as suggesting the existence of spondylolisthesis lumbo-sacralis by the short back, projecting hip bones, and by the peculiar attitude of the body and mode of progression. An inspection of the back and pelvis confirmed my suspicion, which was still further supported by an internal examination of the pelvis which I took the opportunity of making while the woman was under chloroform for the removal of the carcinoma. On account of her age examination per vaginam was of little use; I was, however, able to feel per anum, the lumbar column bending forwards, the angle of dislocation, the lateral angle, described by Breisky, &c. The external appearance of the woman, the sinking down of the thorax into the pelvis, the deep lumbo-dorsal groove, the folds of skin between the thorax and pelvis, the upright, heart-shaped buttocks, with deep lateral depressions over the incisuræ ischiadæ majores, the external kyphotic character of the pelvis, the pendulous belly, and the advanced position of the external genitals, all corresponded to the usual type.

Unfortunately I have not any measurements. The angle of dislocation lay very high, and if one passed the finger upwards along the posterior pelvic wall, could only be reached with extreme difficulty on account of the diminished inclination of the pelvis. It can be easily understood, that as in this sort of pelvis the sacrum is rotated backwards, and the distance from the arch of the pubes to the upper edge (indeed to the whole) of the body of the first sacral vertebra is thereby increased, and therefore the length of the conjugata diagonalis also, the manipulation of the examiner's hand is further obstructed by the con-

* I have counted a case in Rabenau's practice, described by Swedelin, as the first Berlin case.

traction of the pelvis in both transverse and conjugate directions, and one must press up the coccyx and soft parts with a certain amount of force. I may mention on this point that it is much better practically, instead of at first feeling along the anterior surface of the sacrum for the angle of dislocation, which, for example, in the cases of Olshausen and Billeter was indeed believed to exist but not properly reached by the finger, to pass the finger in the anterior vaginal vault or in the rectum directly upwards close along the posterior surface of the symphysis, and try first to feel the lumbar and vertebral column and the so-called false promontory. When the lumbar column is reached, as I have always been able to do without special difficulty in the nine living cases I have examined up to the present, one can then find the angle of dislocation more easily by slipping the finger back along the anterior surface of the lumbar column.

The fact that at times the angle of dislocation and the lumbar column can only be reached with great difficulty, unless the examination is conducted in an appropriate way, may be the reason that spondyl-olisthesis remains undetected in so many cases in practice, especially as during labour the presenting parts of the child make it still more difficult to reach the lumbar column and angle of dislocation with the hand unless the woman is examined standing up, or lying on her side.

When Mrs. H. had recovered from the chloroform, I eagerly sought for a detailed history of her case; it was interesting. She at first denied that she had suffered from any spinal affection, but afterwards admitted that since her 46th year she had had constant sacral pain, which she attributed to hemorrhoids; nevertheless a searching examination of the rectum and genital organs revealed nothing of a pathological character. The history, slight creeping pain in the sacrum and the gradual development, apparently almost without any symptoms, of the externally noticeable deformity, was certainly in favour of the suspected spondyl-olisthesis, although no injury or fall could be remembered. The negative results of the anamuesis recall several of the cases described by others.

That the diagnosis of spondyl-olisthesis was correct is extremely probable, any spondylizema may be at once excluded; any sort of exostosis of the lumbar vertebræ would in the first

place give rise to an abnormal condition to be detected on internal examination, and in the next place would not have caused the changes described in the external form of the pelvis. In any case the olisthesis may be one of no very high degree. Unfortunately nothing definite can be said as to the etiology of this case. The woman went back to her home the same day, and to my regret has not since returned to Berlin.

Third Berlin Case.

Mrs. Clara Fischur, aged 28, the wife of a tinsmith of Brandenberg, applied for advice at the Surgical Clinique of Berlin University, on the 10th September, 1883, on account of sacral pains. The external appearance of this woman also was so strikingly suggestive of spondyl-olisthesis as to make me think at once that such was the case. This presumptive diagnosis was supported by examination of the woman, only leaving a certain indecision between spondylizema and spondyl-olisthesis lumbo-sacralis.

The patient had measles and scarlet fever as a child; menstruation commenced in her 16th year, and she was married when 24 years old. She has had two children, the first in January, 1880, and the second on 2nd April, 1882. The first child was spontaneously, two weeks too soon. The second was extracted by forceps, the head having been arrested for some hours at the pelvic outlet. Puerpery was normal on both occasions, but ever since her first confinement she has suffered from debility, and more or less sacral pain; her figure also has gradually altered so that she has become rather shorter, her hip bones have gradually become very prominent, and her abdomen became pendulous during her second pregnancy. She especially complains of stiffness in the sacrum and inability to exert herself; and in particular that she is unable to carry anything in her arms in front of her from the feeling that she must let her burden fall. It also struck her that during her second pregnancy she could not move about except when she held herself bent very much backwards. She passed through an attack of pneumonia shortly before the end of the first pregnancy, and was at that time bedridden for four weeks.

She cannot call to mind that when she was young she suffered

from an injury or a fall of any kind, but states that even as a child she could not bend herself forwards because of the pain she suffered in doing so, and was often scolded on that account, who, as Mrs. F. characteristically repeated, used to say, "Here am I an old woman stooping down to my work, and you, a young girl, can't do so." While still a girl, and therefore nine years ago, her mother suspecting that she had one high shoulder took her to the local physician, who did not consider any treatment necessary, but said it would grow all right again.

She concluded by saying that when she walks she always has a feeling of fatigue in the sacrum, and is obliged to support herself with both hands on her hips, thereby obtaining immediate relief. She has never suffered from any form of suppuration, nor from rickets, nor does she remember anything of the sort in her family. She had herself learnt to walk by the end of her first year, and apparently developed in due time.

Measurements—

Height	152·0	cm.
Distance between the great trochanters	30·0	,,
,, ,, crests of the ilia	29·5	,,
,, ,, anterior superior iliac spines	28·5	,,
,, ,, posterior superior iliac spines	9·0	,,
,, ,, S angles of the posterior curves of the iliac crests	14·0	,,
,, ,, tubers of the ischia	6·75	,,
External conjugate diameter	19·5	,,
Conjugate diameter of the outlet	6·5	,,
,, ,, cavity	9·	,,
Direct distance from the public arch to the fifth lumbar spine	19·0	,,
False conjugate diagonal diameter	10·0(?)	,,
,, ,, of inlet of smaller pelvis	8·0(?)	,,
Length of the symphysis pubis	6·5	,,

Instead of a minute description of the noticeable points of the individual deformity, which would be almost an exact repetition of that of other similar cases, I give (figs. 1, 2, 3) three drawings showing in the clearest way the external configuration of this woman, in the trace of whose footprints it is most interesting to find that character corresponding to a pelvic spondyl-olisthesis of a moderate degree.

From the drawings and measurements given above it is quite evident that in this case we have to do with a pelvis, externally of the so-called kyphotic character, and with a pelvis obtecta, and *after* the exclusion of other abnormalities, the differential diagnosis

has to be made between spondylizema and spondyl-olisthesis lumbo-sacralis as illustrating which the case is particularly interesting.

From a consideration of the posterior and lateral views of the woman (figs. 2 and 3) it will be seen that though there is no

Figs. 1, 2, 3.—Anterior, posterior, and lateral view of Mrs. Clara F., II-para aged 28.

pathological angle in the upper part of the vertebral column, the fifth lumbar spine forms a projection behind somewhat like a lumbo-sacral kyphosis. One can however convince oneself that the projection is formed by the fifth lumbar spine only, for it can be readily felt above and below, and on either side, and a kyphotic gibbus consisting of one single spine may be said to be

never found except as a cervico-dorsal kyphosis. Besides, if this convexity was kyphotic, or rather as it is in the lumbo-sacral region spondylizematic, the lumbar column would be far more inclined forward *in toto*. The fifth lumbar spine sticks out by itself exactly as in the spondyl-olisthetic pelves at Munich and Zurich, cases in which during life it was thought to be the first sacral spine. In angular pathological kyphosis, the spines of those vertebræ of which the bodies have given way under the action of caries form *in toto* a less acute curve, while here the fifth vertebral spine projects quite independently, and the fourth lumbar spine stands back from it like the step of a staircase. For example, if one compares this profile (fig. 3) with the lateral view of Mrs. Ottilie Grassau,* a woman with a spondyl-olisthetic pelvis, one can immediately see the remarkable difference between the blunt lumbo-sacral convexity of the less acute kyphosis in Mrs. Grassau, and sharply isolated projecting lumbar spine in this case. Between the latter and the rest of the lumbar column there is in this case that angular, saddle-shaped depression caused by the upper part of the lumbar column (that is, the whole of the spinal column down to the fourth lumbar vertebra), and the anterior half of the fifth lumbar vertebra, including the body and anterior half of the ring, upon which indeed the superior part of the spinal column rests directly, has slipped down forwards, while the posterior half of the fifth lumbar vertebra, that is to say its spine, only has remained behind upon the sacrum. Strictly speaking, therefore, this saddle-shaped depression in the posterior aspect of the spinal column lies between the arches of the fifth and fourth lumbar vertebræ, and not directly between the sacrum and lumbar vertebral column. Indeed the character of this angular saddle-shaped depression is so typical, that in itself it seems sufficient to exclude spondylizema in this case as against spondyl-olisthesis.

In the next place, in spondylizema, as has already been pointed out, the spinal column and upper part of the body would be inclined more forwards, as is represented in the picture of Mrs. Grassau that has been referred to; but in Mrs. F. the

* Neugebauer, "Zur Casuistik des Spondylolisthetischen Beckens," *Archiv für Gynäkologie*, Bd. xix., Hf. 3, S. 448, fig. 3; or Winckel, *Klinische Beobachtungen zur Dystokie durch Beckenenge*. Leipzig, 1882, Tafel II., fig. 6.

attitude of the upper part of the body is one still inclined backwards. In olisthesis the body is not bent over forwards till the degree is extreme.

Thirdly, there are no statements in the anamnesis to be referred to the development of a spondylizematic pelvis. And yet such a development is never so completely hidden; the characteristic group of symptoms associated with Potts' curvature are familiar enough to be omitted here. On the other hand, the development of spondyl-olisthesis is, for the most part, almost without symptoms, but rarely rapid, and occasionally its gradual progress is greatly promoted by intercurrent pregnancies.

Now in the present case some anomaly had existed ten years previously, for the girl, though almost quite healthy, could not bend herself forwards, and from her first conception the deformity was continually becoming greater, especially so during her second pregnancy, from the renewed and continued increase in the weight on the lumbar column.

Five days after the first examination I took the woman to the Berlin University Clinique for the Diseases of Women, and asked Herr Schröder, and Herr Müller of Bern, who was present at the time, to examine her. The apex of the angle of dislocation could not now be distinctly felt, and the soft parts about it were so considerably swollen, almost fluctuating, as to suggest the possible presence of a commencing, descending abscess at the promontory of a well-marked Potts' kyphosis of the lumbo-sacral region. This caused Herr Schröder and Herr Müller to have some doubt as to whether the case was not one of spondylizema. This swelling of the soft parts struck me the more, as it had not been so considerable five days before at the time of my first examination, after which the woman had suffered for twenty-four hours from pain in the abdomen. I had, on that first occasion at the general clinique, on account of the great interest afforded by the case, allowed a large number of medical men and students to examine the woman, and it is quite possible such repeated examination was not without results. Besides, a quite similar swelling of the soft parts existed on the examination of Henriette R. of Halle, Amalie H. of Dresden, and Francisca D. of Prague. And this circumstance is no evidence against olisthesis, for it may well be admitted that such marked deformation and disloca-

tion of the vertebral column cannot take place without an accompanying condition of irritability in the surrounding soft parts. Quite apart, however, from this, and from the history of the case, several other points corroborate the diagnosis. As has been stated, the angle of dislocation was on one occasion felt below the level of the anterior superior margin of the os sacrum, while in a case of lumbo-sacral spondylizematic kyphosis the apex of the angle of flexion is situated exactly at this margin, and therefore the finger tip passing outwards on either side from this angle of flexion must hit upon the anterior edges of the lateral masses of the sacrum. Moreover, the thickness of the posterior pelvic wall in a median plane at the level of the plane of the pelvic inlet is evidently too great; the posterior pelvic wall now consists at this place of the body of the fifth lumbar vertebra + the body of the first sacral vertebra, the posterior arch, and the spine of the fifth lumbar vertebra, a diagnostic mark on the value and mensuration of which, by means of subtracting the direct thickness of the posterior pelvic wall at this part from the length of the external conjugate diameter, and so getting the length of the false conjugate, I have already written in my earliest work and elsewhere.*

We have, finally, the assistance of the characteristic condition of the solid angle of Breisky, as well as the circumstance that to reach the lateral parts of the anterior superior margin of the base of the sacrum one must on each side pass one's finger upwards along the posterior pelvic wall above the depressed body of the fifth lumbar vertebra. The history of the case, its course and symptoms, the progress of the development of the existing deformity, the attitude of the body, &c., all give additional support to the clinical presumptive diagnosis, every objection to which may in the face of these circumstances be considered removed, as indeed Herr Schröder himself considered.

Mrs. F. had stated that she found relief if she supported

* *Zur Entwickelungeschichte des Spondylolisthetischen Becken's u.s.w.*," S. 36, ff.

"A further peculiarity of the spondyl-olisthetic pelvis is found theoretically and practically in the position of the lumbar vertebræ (especially of the fifth lumbar vertebra) in front of the first sacral vertebra. The increase in the direct thickness of the posterior pelvic wall at the level of the base of the sacrum which this causes, leaves a striking difference between Baudeloque's diameter and the conjugata pseudovera, &c."; and S. 37, "If in certain cases we were able to measure with instruments the thickness of the posterior pelvic wall, the estimation of the conjugata spuria from Baudeloque's diameter would (*sic*) be possible," *et sequent.*

herself when walking by placing her hands on her hips. It was, therefore, only following the hints of nature for us to lessen, as far as possible, the burden on the lumbo-sacral joint by a supporting apparatus, as I had already done in a case at Halle, where Volkmann had also done it in a case of his own. I applied a provisional plaster of Paris corset to the woman in Sayers' sling, with the assistance of Dr. Barth of Berlin, intending if this was of the desired benefit to have a felt splint apparatus made for the case. The patient felt immediate relief after the application of this corset, and journeyed home contentedly. On the 25th and 27th September she wrote to me, saying that the corset had been for the first few days rather uncomfortable and burdensome to her, but that now she could sleep better at night, and get about better in the day time, and was very contented with it. The corset must indeed relieve her, but how will it be with the deformity?

As a rule the development of the latter is only arrested when in the stage of complete spondyloptosis the bodies of the two vertebræ concerned form with each other a right angle, or even an acute angle. Then if the arch of the fourth lumbar vertebra has come to rest almost directly upon the first sacral vertebra—that is to say, if the body of the first sacral vertebra has then been forced so far into the aperture of the vertebral canal in the fifth lumbar vertebra, that either it has completely separated the anterior and posterior halves of the arches of the fifth lumbar vertebral ring, or the interarticular portions of the ring have elongated and wasted away under the extreme pressure—no further elongation of the arch of the fifth lumbar vertebra results; the body of the fifth lumbar vertebra then lies entirely against the anterior surface of the sacrum, its axis quite perpendicular, or even at an acute angle to that of the first sacral vertebra. Now, then, should every attempt to lessen the pressure be abandoned in order to promote the development of the deformity to this extent? Fortunately this is not the case, for experience has shown that an arrest, and consequently a cure by synostosis, may take place at any stage of spondyl-olisthesis. Another pregnancy would be the most likely thing to render all curative treatment useless. I will however, if possible, keep the case under observation, and hope to be able to give an occasional report of this attempt at the orthopœdic treatment of the disease.

Third Strasburg Case.

On page 53 of my earliest work I said*:

"Experience has not taught me that I undertake too much in promising to recognise any woman with a spondyl-olisthetic pelvis among the throng in the street."

The peculiar appearance of such persons has become still more familiar to me since I wrote this. It was on the 7th October of last year that Dr. Swedelin, of St. Petersburg, and I met in Strasburg in one of the streets by the Minster a woman in the costume of Alsace, whose external appearance was so striking that I looked at her more carefully. Both the manner in which she held her body, and her mode of progression, were those of spondyl-olisthesis lumbo-sacralis. When I had learnt, through a third person, that she suffered from sacral pain, had been delivered by forceps, &c., &c., I soon got the good woman to come to the Gynæcological Clinique, where I could justify the accuracy of my presumptive diagnosis to my friend. In it Doctors Freund, Haeckel, and Swedelin completely concurred, and the following representations should remove any doubt of it:—

Measurements—		
Height	154·0	cm.
Distance between the iliac crests	32·0	„
„ „ great trochanters	31·0	„
„ „ anterior superior spines	28 0	„
„ „ posterior „	9·5	„
„ „ S angles of the iliac crests	14·0	„
„ „ tubers of the ischia	6·7	„
Conjugate diameter, external	18·0	„
„ „ normal	18·5	„
„ „ of the cavity	10·0	„
„ „ of the outlet	7·5	„
„ „ to angle of dislocation	12·0	„
„ „ to most prominent part of the lumbar vertebræ	?	
„ „ false.....about 9·5 cm. to	10·0	„

The pelvis was slightly unsymmetrical from scoliosis. A simply unilateral olisthesis could not be certainly made out. While the lordotic lumbo-sacral groove was very deep, on account of the thickness of the integument, and the plentiful development of subcutaneous adipose tissue could be but very indis-

* *Zur Entwickelungsgeschichte des Spondylolisthetischen Beckens und seiner Diagnose* (mit Berücksichtigung vom Korperhaltung und Gangspur), mit 97 Holtzschuitten im Texte Halle und Dorpat, 1882.

tinctly made out, on the other hand the sacral hiatus, and the fourth and third sacral spines, were easily felt.

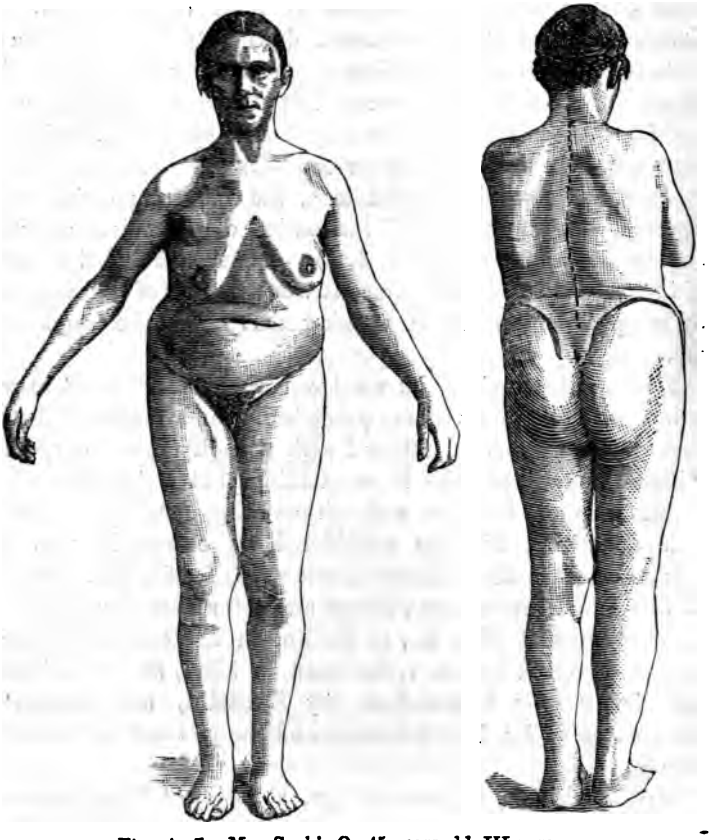
The spinal column exhibited a compound scoliotic rotation—in the cervico-dorsal portion to the right, in the dorso-lumbar to the left, and in the lumbo-sacral back to the right; the right hip projects more backwards, and at a greater angle with the trunk than the left, on which side the line from the axilla to the crest of the ilium is straighter or more easily curved. The thorax is turned about, and sunk down into the pelvis, as the folds of skin across the abdomen above the pubes show. The rotation inwards of the lower end of the sacrum and the coccyx is evident externally from the prominence of well-marked lateral depressions in the buttocks corresponding to the greater sciatic notches. The pendulous abdomen, the anterior position of the genitals, and the diminished inclination of the pelvis, can all be seen in the pictures (figs. 4, 5, 6). I have also added a picture of the woman in costume, since it was this view of her, supported by her peculiar manner of walking, that forced the diagnosis on me.

These pictures show the most remarkable agreement in most points with the many others published. As a matter of fact the appearance of a person affected with a high degree of spondylolisthesis lumbo-sacralis is so striking that it impresses itself on the memory for ever, and without any special examination this deformity, hitherto considered an extremely rare one, betrays itself in the ordinary intercourse of daily life. In proof of this I will insert here without any comments figs. 9, 10, 11, which represent Mrs. R., of Berlin, in her ordinary dress, a woman delivered by Dr. v. Rabenau in 1883, and described in the *Archiv für Gynäkologie* by Swedelin, and suggest a comparison of fig. 7 of this work and the pictures in Swedelin's article.

Mrs. Sophie O., 45 years of age, a native of Nymphersheim, and the wife of a joiner in Strasburg. As a child had always good health, and was well developed, but while still a young girl she was subject to sacral pain, and was never able to lift up anything heavy from the ground, or to carry it; she was particularly unable to carry anything in front of her. She has had three children; her first labour, eleven years ago, was comparatively easy; the next, eight years back, more difficult; and one

a year ago, when as the head remained for more than three hours at the outlet, Dr. Hueter had to deliver with the forceps. Since the last delivery but one, the sacral pains have increased, and a deformity has developed ; the patient has got shorter, and her hips have gradually become more prominent in the mean-

Fig. 4. Fig. 5.



Figs. 4—7.—Mrs. Sophie O., 45 years old, III-para.

time, but especially during the third pregnancy her abdomen has become pendulous to a burdensome extent, and her previously normal gait has turned to a waddle.

The track of her footprints (fig. 8) is that characteristic of a person with a pelvis of an externally kyphotic form which I have

fully delineated in my previous works. I would only add that with the waddling gait like that of a duck the upper part of the body sways freely from side to side.

Fig. 6.

Fig. 7.

Herr Hueter, of Strasburg, informed me that he never saw the woman again after her delivery. As he found the head already lying in the outlet, he made no exploration of the pelvis, and only states that the outlet was very decidedly contracted transversely.

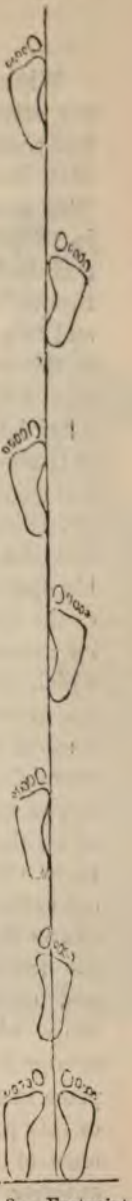


Fig. 8.— Footprints of Mrs. Sophie O., $\frac{1}{5}$th natural size.

Case at Paris.

When I was visiting Professor Charpentier in Paris, he drew my attention to the striking resemblance which a woman he had seen in 1868 bore in external appearance to the picture of Mrs. Berndt (see fig. 13, inserted for comparison, on page 39). This woman had been a patient in the Obstetric School at Paris in 1868 for her fourth confinement, which terminated naturally, and the late Professor Depaul, at that time director of the institution, had diagnosed a congenital dislocation of both femora, and two photographs taken at the time were afterwards inserted in the text books as typical of the appearance of the trunk in this dislocation; for example, in Charpentier's own text book, *Traité des Accouchements*, Tome ii., p. 116, figs. 418, 419; and in Guéniot's treatise, *Des luxations coxo-fémorales soit congénitales, soit spontanées au point de vue des accouchements*, Paris, 1869, pp. 108, 109, figs. 11 and 12. Was this woman's pelvis really one with bilateral femoral luxation, or was Depaul mistaken in his diagnosis? I do not myself think there was any dislocation of the femur in the case; at first sight the waddling gait (*marche en canard*), which is a characteristic of these dislocations, but which is often associated with a spondyl-olisthetic, together with the general deformity and shortening of the body, might well suggest such luxation; besides which the symptomatology of the spondyl-olisthetic pelvis was at that time little understood, had indeed been so little studied that this affection of the pelvis was as a rule overlooked. A careful consideration of these pictures (figs. 12—14) will, however, at once show that the trochanters are in their normal position; that the greatest width of the pelvis lies in the line between the iliac crests, and not in that between the trochanters; that the shortening is in the lumbar region, and not in the upper thighs; that the pelvis corresponds in shape with the so-called kyphotic pelvis, that is to say the change it has undergone is exactly opposite to that which takes place in luxatio duplex femorum iliaca. The shape and position of this pelvis, its diminished inclination, the prolonged appearance of the lower extremities, the form of the buttocks, the anterior position of the external genitals, and the general external configuration, most certainly indicate not only that *there is no* luxation of the femora, but that there was here some

Fig. 9. Fig. 10. Fig. 11.

Fig. 9—11.—Anterior, posterior, and lateral view of a woman with a spondyl-olisthetic pelvis (spondyloptosis).

form of the pelvis obtecta, and that that form is either spondyl-izematic or spondyl-olisthetic, and since the posterior view proves the absence of any projecting gibbus, the pelvis must consequently have been spondyl-olisthetic.

For the rest, Doctors Charpentier, Guéniot, Tarnier, Porak, Doléris, Trélat, Desprès, and several other Parisian obstetricians and surgeons, to whom I stated this deduction, completely agreed with it.

I will not argue further in favour of my view of the case, as I believe these drawings afford a proof of its accuracy, and will only mention a most simple key to the analysis of such cases by the proportions of the pelvis in length and breadth.

By a comparison of figs. 15, 16, 17, and 18, we can see that if in each of these diagrams we lay down the bitrochanter line A B, the line joining the crests of the ilia C D, and if on either side join A to D and B to C by straight lines A D and B C produced to meet on that side to which they converge, these lines from the iliac crests to the trochanters will intersect in some point E, which in the normal pelvis (fig. 15) lies a long way above the bitrochanter line, in the luxation pelvis (fig. 16) it lies considerably lower down, while in the spondyl-olisthetic pelvis it lies below the bi-trochanter line.

In the first case, and also in the second, the figure A B C D forms a trapezium with the base downwards; in the third case the base of the trapezium is the upper line C D; or taking the isosceles triangle A B E, in the two former cases the apex E is situated above the pelvis, while in the third case it is below it. The shape, height, and width of the trapezium and triangle are of course quite different in the three cases, and are typical in each diagram. Now in an outline sketch of Depaul's case (fig. 18), treated in the same way, the base of the trapezium and of the triangle is formed by the bitrochanteric line, though in this case the triangle is not isosceles, its apex being displaced to the right by the existing scoliosis. The variation in the figures here shown has its primary basis in the alteration of the position of the hip bone in relation to the femur.

The changes in the shape of the pelvis are represented diagrammatically in the transverse perpendicular section of the pelvis (fig. 19). In the normal pelvis A B C D, straight lines drawn through the sides of the pelvis intersect when produced at

Fig. 13. Fig. 14. Fig. 12.

Figs. 12 and 14.—Anterior and posterior view of a woman delivered naturally of her fourth child at the School of Obstetrics at Paris, in the year 1868, during the direction of Professor Depaul, the presumptive diagnosis *ex aspectu* being pelvis spendyl-olisthetica (drawn on a diminished scale from a photograph).

Fig. 13.—Minna B., aged 26, in her second pregnancy, inserted for comparison (from Neugebauer's paper, *Archiv. für Gynäkologie*, Bd. xix., S. 448, fig. 1).

the angle X, in the luxation pelvis under consideration, these lines intersect at an angle Z, which is more acute, and of which the apex lies lower down, while in the spondyl-olisthetic pelvis the angle of intersection is more obtuse, and its apex lies higher up. Corresponding to the alteration in the pelvis, the hip bones, apart from their characteristic change in shape, their increased or diminished length from behind forwards, are rotated outwards in the spondyl-olisthetic pelvis with a decrease, and in the luxation pelvis in the opposite direction, as is shown by the arrows in the diagram.

Direction of Rotation of the Hip Bone.

The height, *h h*, of the pelvis, &c., &c., is proportionately altered. This diagram is only designed to illustrate the fundamental principles above-stated, and therefore all other marks of the two anomalies are omitted, indeed I have not even inserted the head of the femur in its dislocated positions, because there are various forms of this dislocation, each of which would require a separate diagram. Nor have extreme cases been held in view; what has been said is borne out by ordinary cases.

In spite of all my efforts I could unfortunately learn but little of the history of the labours or sickness of the Parisienne G. The scanty notice in the journal only stated that on the 18th May, 1868, Elise Guinot, a milliner, aged 27½, was admitted into this institution in her fourth confinement, the three previous ones having been premature. She was delivered on the 20th May after a natural labour, and discharged on the 1st June. The infant was healthy, weighing 3,160 grammes.

In reference to the anamuesis it is said (*l. c.* in Guéniot): "1st pregnancy, abortion at three months and a half; 2nd pregnancy, abortion at six months; 3rd pregnancy, labour at term, prolapse of the cord caused the application of forceps; 4th pregnancy, natural labour."

Finally, there is a remark in pencil writing in the Clinical Journal of the confinements: "The patient has a considerable convexity at the level of the lumbar region."

This last notice is of special interest, inasmuch as it appears to contradict my deduction as above. In the meanwhile a *careful* consideration of the back view in the original photograph

Fig. 15.

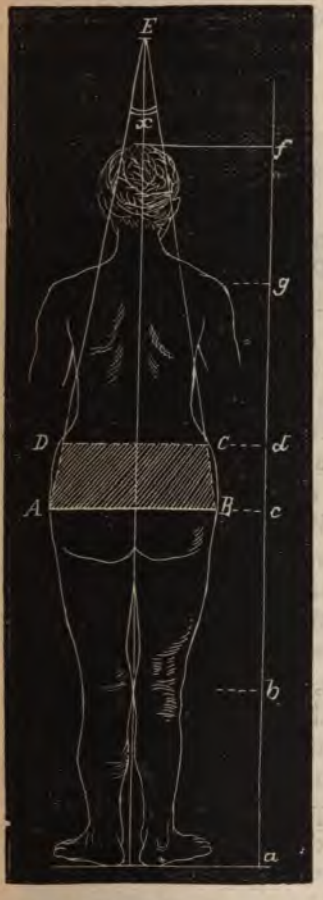
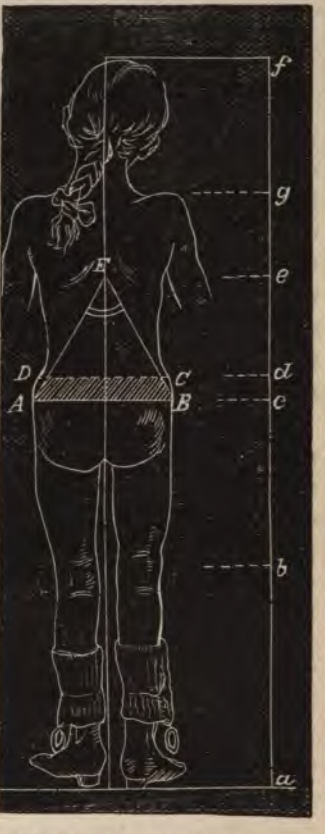


Fig. 16.



Figs. 15—18.—Outline diagrams (Figs. 15, 16, and 18 drawn from photographs).
Fig. 15.—Normal configuration (See Neugebauer, *Archiv für Gynäkologie*, Bd. xix., S. 450, fig. 4).
Fig. 16.—Configuration in luxatio femorum congenita iliaca duplex. (After Hamilton.)

shows that no convexity in the sense of a spondylizematic pelvis existed, it is therefore probable that the term "considerable convexity" was applied to the very prominent lower part of a spondyl-olisthetic lumbar saddle, that is, to the base of the sacrum, together with the fifth lumbar spine.

A few weeks ago chance once more threw in my way an observation that is, I think, appropriate here. My attention was attracted by the peculiar conformation of a woman 26 years old, the daughter of a master baker, P. Unfortunately all my efforts to arrange for a proper examination of the case were upset by the opposition made by her and her relatives. I have nevertheless no hesitation in going into the case, for I entertain a firm opinion that sooner or later the maiden, provided she gets married, will come under medical observation; I have particularly recommended her to the attention of a colleague in Paris.

Miss P., as a child, well-formed, and well-developed for her age, free from hereditary disease. When 2 years old she had a fall, and since that time until two years ago has suffered more or less, and was for ten years under medical treatment. Her first symptom was a difficulty in moving about, followed by vague pains in the sacral and lumbar regions; she was never bedridden for any considerable time, and her illness was of an insidious character with few marked symptoms. At first one knee was treated with sinapisms; later on the affection moved up to the loins. The most prominent mark of the disease was a very gradual shortening of the upper part of the body and lateral growing out of the hips. Her dresses became too long for her; her attitude, however, remained upright, and she had no forward stoop. There was never any fever or suppuration, or anything of the kind, and her general condition as to nourishment and strength was always good. For the last two years the pains in the sacral region have more or less gradually disappeared, so that at present she does not feel ill. This is all I was able to learn. Her external appearance bears the closest resemblance to that of Mrs. R. of Berlin (*vide* figs. 9—11 of this work), but unfortunately I cannot exhibit a single picture of her. From her

Fig. 17.

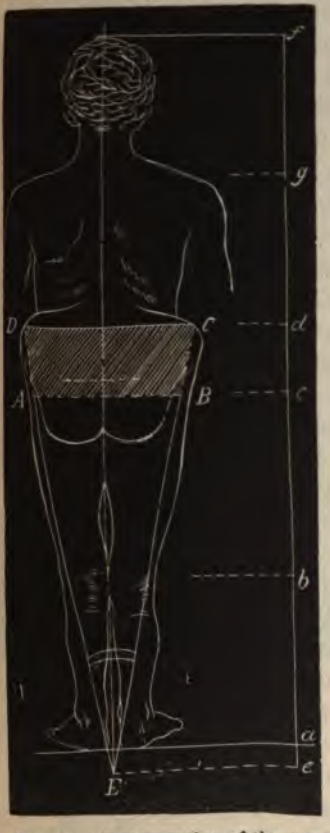


Fig. 18.

Fig. 17.—Configuration of the spondyl-olisthetic pelvis. (See Neugebauer, *loco cit.*, fig. 6.)

Fig. 18.—Configuration of the Parisienne G. (From a photograph taken by Depaul in 1868.)

AB Bitrochauter line.

CD Bicristal line.

E Point of intersection of the lines from the trochanters to the crests of the ilia when produced on the side of their convergence.

external appearance and gait she certainly has in my opinion a pelvis obtecta of an outwardly kyphotic character, and both from her exceedingly upright attitude, and from the history of the case, I believe that she has a spondyl-olisthethic pelvis. Potts' disease in the lumbar region, or Herrgott's spondylizema, may exist without any sinking down of the spinal column over the pelvic inlet, and without forming any characteristic convexity, but I doubt whether a high degree of pelvis obtecta spondylizematica can occur without a hump or without decided inclination forwards of the upper trunk. I would also refer to the differential diagnosis between *spondylizema* and *spondyl-olisthesis* in the case of Mrs. Ottilie Grassau, of Dresden (*vide* Neugebauer, *Archiv für Gynäk.* Bd., xix., Hft. 3, fig. 3, &c.).

From my past experience I might reckon this as the second, or, if the Hottentot Venus is counted, as the third Parisian case of spondyl-olisthesis. I will, however, at present simply mention it here as the results of a more exact internal and external examination have still to be obtained, and I have not even a picture to illustrate the case, moreover all possible care has been taken to secure sooner or later the particulars of the case for the benefit of science. If the presumptive diagnosis I made from her appearance is not correct, no loss can in any case result to our diagnostic knowledge. May I be allowed to add here some explanation of the difference of opinion existing between Herrgott and myself in respect to the genesis of spondyl-olisthesis?

As is well known, Herrgott (sen.), of Nancy, published in his time several works upon the spondyl-olisthetic and the lumbo-sacral kyphotic pelves, and made use of the expression "spondyl izematic" pelvis to describe the latter (*σπόνδυλος* = vertebra, and *ἴζημα* = sinking, depression, *Lusammen-sinken*).

In this Herrgott essentially improved the nomenclature of the pelvis. In Germany we are in the habit of speaking of a pelvis as kyphotic if we mean the pelvis of a person affected with kyphosis of the vertebral column, but in these cases the pelvis itself is not in the least kyphotic, its posterior wall exhibits no hump of any kind, but it is a pelvis changed in shape by the body weight in consequence of a kyphosis of some part of the vertebral column, be the same higher up or lower down, though *it is true* that this change in shape varies in degree according to

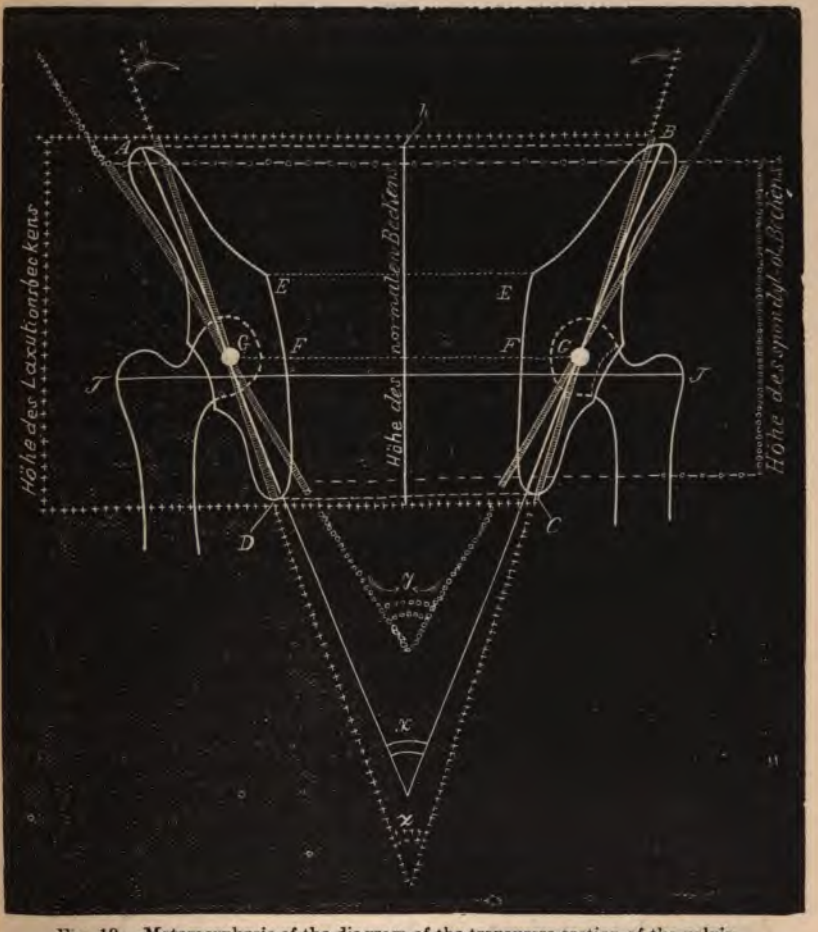


Fig. 19.—Metamorphosis of the diagram of the transverse section of the pelvis.

——— Normal pelvis.

++++ Pelvis with luxatio femorum duplex iliaca congenita.

oooooooo Spondyl-olisthetic pelvis.

AB Line between iliac crests.

TT Bitrochanter line.

EE Transverse diameter of inlet
FF „ of hollow } of the pelvis.
CD „ of outlet

GG Transverse axis of the pelvis.

hh Height of normal pelvis.

x Angle of intersection of the straight lines through the sides of the normal pelvis, produced.

y Angle of intersection of those of the pelvis with luxatio fem. iliaca congenita.

z Angle of intersection of those of the spondyl-olisthetic pelvis.

Direction of rotation of the hip bone.

the position of the kyphosis. The pelvis itself is kyphotic only when its posterior wall has a share in the formation of the hump (κῦφυς). But from an obstetric point of view the anatomical character of a kyphotic pelvis varies so much with the situation of the kyphosis, that it seems to be essentially desirable to distinguish at all events the principal forms of it by different expressions; and unless we are willing to use the expression kyphotic pelvis only in cases of lumbo-sacral kyphosis, and to describe the other cases as pelves with dorsal kyphosis, &c., a separate description of the lumbo-sacral kyphotic pelvis, such as Herrgott has invented for it under the expression spondylizematic, is very desirable, and we can then continue to include under the term kyphotic those pelves in which the kyphosis is situated higher up, though the term is not strictly accurate. A separate description of the lumbo-sacral kyphotic pelvis seems the more necessary, since it is always of a character essentially different from any other so-called kyphotic pelvis. While in the latter the change in the dimensions of the smaller pelvis has alone to be considered, in the former the size of the greater pelvis is altered, and there is a contraction in its conjugate diameter of much importance in obstetrics. In the lumbo-sacral kyphotic pelvis we have a "pelvis obtecta," which obstetrically is twice as important as any other so-called kyphotic pelvis. Moreover a description of the lumbo-sacral kyphotic pelvis different from the spondyl-olisthetic is most desirable for diagnosis, and consequently Herrgott's expression spondylizema is doubly welcome.

Now Herrgott has wished to include spondyl-olisthesis and spondylizema in one general group of pelvic deformities caused by one and the same process, Potts' disease, and has made this distinction between them.

(*a*) If the bodies of the vertebra are affected and lose their resistance, the spinal column sinks downwards and forwards with the formation of a lumbo-sacral hump (in consequence of their obliteration)—spondylizema.

(*b*) But if it is the vertebral arches which are affected and lose their resistance, so that they can no longer effectually oppose the tension caused by the pressure on the lumbar vertebral body, the body of the fifth lumbar vertebra slips down forwards, resulting in spondyl-olisthesis.

In French literature this view of Herrgott's has been so

generally adopted up to the present time, that for example Charpentier in his lately published text book in 1883 does not even enter on the discussion of other and more recent theses, and even sets down in a categorical manner Potts' disease as the unique cause of spondylizema and spondyl-olisthesis, although this view has long ago been set aside, and as we shall see further on, is now abandoned by Herrgott, its originator, himself.

In my previous works I have given prominence to the proof that in relation to its origin, spondyl-olisthesis differs most essentially from spondylizema; for while in the latter there is a specific caries with loss of substance, and with or without suppuration, that is to say Potts' disease, in olisthesis there is neither caries nor loss of substance, and up to the present time caries, even when affecting the vertebral arches, has in no single well proved case caused olisthesis properly so-called. (In the cases of Blasius and Ender it appears to me that the diagnosis was by no means established.) I have looked upon spondylizema, *i.e.*, Potts' curvature, more as a deformity caused by a dyscrasia, spondyl-olisthesis on the other hand as purely surgical, and have referred the genesis of the latter exclusively to a congenital defect in ossification, or to a corresponding fracture.

Herrgott having become acquainted with my works, has done me the honour to translate into French as much as relates to the etiology of spondyl-olisthesis (*vide Annales de Gynécologie*, Mai 1883: "Spondylizème et spondyl-olisthésis, nouveaux documents pour l'étude de ces deux espèces de lésions pelviennes") and has taken up the following position.

In the first place, Herrgott does not appear to be quite willing to admit the cases of spondyl-olisthesis developed on the basis of congenital spondylolysis, *vide l. c.*, p. 329: "We do not think it necessary to mention (in the list of spondyl-olisthetic pelves given by Herrgott) either the pelvis of the Hottentot Venus or the pelvis at Bonn, the documents about which do not appear to us to be sufficiently accurate." But since this mode of origin is proved in the cases of olisthesis of damaged vertebræ at Breslau and Berlin, and in the two pelves at Wurzburg, &c., the doubt as to the spondyl-olisthesis of the Hottentot Venus might well be abandoned.

In reference to the other cases referred by me exclusively to a

fracture of the arch of the fifth lumbar vertebra, or of the sacral articular processes, Herrgott attributes the development of the deformity not to this fracture, but to a loss of resistance in the lumbar vertebral arches due to inflammation.

On page 350, "It is evident that the vertebra must lose its normal resistance." "One cannot admit more than two possible causes of this effect; the arch supporting the articulations must be broken or softened—broken by some violent injury which would cause the displacement immediately, or softened by pathological action." "Since then," Herrgott continues, "the olisthesis does not occur suddenly but gradually during the long years duration of the disease," he decides for the latter mode of genesis, the rather so as "manifest traces of bony inflammation, osteophytes, osseous rarefaction (osteoporosis ?), loss of bone substance," are to be found, "everything to prove that a chronic inflammatory process has accompanied the evolution of the lesion."

On page 351 it is stated, "We were not, therefore, so far from the truth when we said that the same affection, of the nature of chronic inflammation (we said caries, which while incontestable for the body of the vertebra may be less exact for the arch), attacking two different parts of the vertebra may be the cause of two pelvic deformities essentially different.

Herrgott says in conclusion, p. 352, "We equally regret not to be able to admit completely the final conclusion of Neugebauer, which is thus stated, 'Spondyl-olisthesis is a surgical deformity, which is sometimes caused by an anomaly in the ossification of a vertebral arch, but which is more frequently caused by an injury.'"

The view of Neugebauer, it is said, moreover, "appears less satisfactory to us than the one which we have given, for it does not attribute to inflammatory action the important *rôle* that it appears to us belongs to it. If the injury was the efficient cause, the deformity would immediately follow it, which is not the case; a time, short or long, and most frequently very long, months, even years, pass away before the deformity is produced; the latter does not come on until the inflammation has accomplished its modifying action on the consistence of the vertebra, which becomes unequal to the maintenance of the continuity of the column."

I would to this reply as follows: in the first place, Herrgott

has now abandoned the Potts' disease he formerly insisted on, and refers the loss of resistance in the interarticular portion of the vertebral arch to "a chronic inflammatory state." Now then, by what has this state of chronic inflammation and giving way been called forth? Was it primary? Surely not. By what then was it caused? By a fracture, an injury? I refer the genesis of the olisthesis to this injury, without which the chronic inflammatory process of Herrgott would not have occurred, and consequently there would have been no olisthesis. Herrgott, on the other hand, refers the genesis to the condition of the vertebral arch that I assert is secondary, yet he himself says on pp. 350, 351: "This chronic inflammatory state of irritation is according to the history generally caused by an injury."

He quotes the statements from anamneses brought forward by me as examples, in regard to ascertained fractures and injuries and says, *es seien dies.*

"All traumatic actions the maximum result of which must affect the lumbo-sacral region."

"Is not the most frequent cause of chronic osseous inflammation to be found in these?"

"Once the inflammatory condition following injury is admitted the process becomes clear." Such a deformation of the bone as we see can only be produced if the bone has lost its resistance under the chronic influence, for then alone can it be extended and flattened out, and undergo such transformations under new statical conditions. "In one word, as origin of the lesion we look upon an injury which need not break the bone, it may be some other injury, but which inflames it, causes it to soften, and allows the entire metamorphosis to take place."

In the first place, it is not true that a fracture must cause the deformation to arise at once, that is to say, immediate dislocation. It may do so, but there is no must in the case. The dislocation after fracture is indeed very often only brought about by secondary influences, internal or external, muscular tension, overburdening during the process of union, or something of the kind, as soon as the force of the full blow or other injury has already been exhausted on the resistance of the bone Indeed the appearance (*eintritt*) of the dislocation of the fragment may be separated to a certain degree in time from the fracture; for example, dislocations and deformities often occur in consequence

of unsuitable bandaging apparatus, that would sometimes not happen had the repair been left to nature. And Herrgott says also (p. 352): "We much regret that we cannot completely agree with Neugebauer's final conclusion, which is thus stated: 'Spondyl-olisthesis is a surgical deformity, occasionally due to some anomaly in the ossification of a vertebral arch, but more frequently caused by an injury.'"

"Neugebauer's view," he states further on, "appears to us less satisfactory than our own, for he does not give to inflammatory action that important part in the matter which it appears to us to play. If the injury was the effective cause, the deformity would be an immediate result, and this is not the case; more or less time, and generally a very long time, consisting of months, or even years, elapses before the deformity, which does not arise until the consistence of the vertebra is so modified by inflammation that it is too feeble to support the rest of the spinal column, is produced."

In answer to this I would in the first place point out that Herrgott has now abandoned the causative action of Potts' disease he formerly insisted on, and attributes the loss of resistance in the interarticular portion of the vertebral arch to a "chronic inflammatory condition." But to what is this chronic inflammatory state and softening itself due? It cannot be a primary condition, but is itself due to some fracture or injury. While I look upon this injury, without which neither Herrgott's chronic inflammatory softening nor olisthesis could have occurred, as the origin of this olisthesis, Herrgott, on the other hand, refers the genesis of the olisthesis to a condition of the vertebral arch which I insist was secondary, and says, nevertheless, on pp. 350, 351, "This chronic inflammatory state of irritation is according to the anamuesis generally due to an injury."

He enumerates all the fractures and injuries mentioned in the anamuesis of the several cases which I have set down, and then says, "The maximum effect of all of these injuries must result in the lumbo-sacral region." "Have we not here the most frequent cause of chronic inflammations of the bone?" "Once the inflammatory condition RESULTING FROM INJURY is admitted, the process becomes clear." "The defermation of the bone, such as we see, can only result if the bone has lost its resistance *under some* chronic influence, for only then could it be elongated,

flattened out, and under the altering statical conditions undergo such transformation; in one word, as the origin of the lesion, we look on an injury which does not break the bone (the lesion may be quite different), but which inflames it, softens it, and allows all that metamorphosis to take place."

Now it is not true that the deformation or dislocation must be an immediate result of the fracture. It might, but by no means must be so. Indeed many a dislocation occurring after fracture is secondary, due to internal or external influence, muscular tension, strain during the process of repair, or some similar cause, the power of the fall or blow, or whatever it may be, having exhausted itself on the resistance of the bone, or a dislocation of the broken fragments may not happen till some time after a fracture, and we know that dislocations and deformities which would perhaps not have occurred if the cure had been left to nature, are not infrequently caused by improper bandaging. So in olisthesis the injury, or fall, causes the fracture, and then the predisposition to olisthesis, due to the weight of the body, necessitates the deformity, or rather the deformation. That from the alteration in the statical conditions or deformation, as well as in consequence of the fracture, infraction, or other injury itself, a chronic inflammatory condition of the bones does arise, and plays a certain part in the olisthesis, is self-evident, and has never been denied. But this inflammatory condition is always secondary, and therefore is not the cause of the spondyl-olisthesis, but is only a process accompanying it, and is like it, a result of the injury; the spondyl-olisthesis itself is therefore due to the injury.

However, Herrgott himself says this chronic inflammatory condition, put forward as the controlling cause, is a result of the injury.

The difference, therefore, between Herrgott's view and my own is only that he looks upon a chronic inflammatory condition of the vertebra, itself due to an injury, as that primary cause, which I find in the injury itself, for without the latter that "primary" chronic inflammatory condition would never have existed. It is essentially a difference in words only, for Herrgott, with whom I had an opportunity of conferring personally in Nancy not long ago about it, explained to me that in distinguishing between spondylizema and spondyl-olisthesis he had not intended to insist

that both affections were due to the same specific process, *i.e.*, to Potts' disease, but rather to indicate that spondylizema was a result of a softening or dissolution of the body of the vertebra, and was therefore due to disease of the body of the vertebra, while spondyl-olisthesis was a result of disease (=*ramollissement*, softening) of the arch of the vertebra, even if this disease was itself due to an injury.

At Friburg, towards the end of September, I received from Professor Frankenhäuser, to whom I would here express my thanks for his prompt courtesy, the Zurich pelvis for examination. In one half of the specimen I softened off the ligaments, and separated the fourth lumbar vertebra *in toto* from the fifth, so as to expose the *corpus delicti*, the fifth vertebral arch, and I removed as far as was necessary and possible the irregular attachments from both halves of the preparation. I found unmistakable traces of a fracture, which I had previously suspected *a priori*, on either side of the interarticular portion of the fifth arch. The conditions were very similar to those found in Olshausen's pelvis at Halle, in that at Liège, and to those in the B pelvis at Prague, in particular.

Without any detailed description of this interesting and fatal Zurich pelvis, I may illustrate the condition of the affected parts, *i.e.*, of the lumbo-sacral symphysis, by a few drawings. The olisthesis had, as is known, reached the stage of spondyloptosis; the body of the fifth lumbar vertebra lay well within the true pelvis, while the posterior part of its arch, and its isolated and extremely prominent spine, remained in the normal position; the body of the first sacral vertebra has been forced like a wedge into the lumen of the vertebral canal of the last lumbar vertebra, with proportionate enlargement of this lumen from behind forwards, and it is therefore quite evident that the interarticular portions of the arch of the last lumbar vertebra must be lengthened to the same extent that the body has been separated from the posterior transverse part of the arch. In fig. 20 the fifth lumbar vertebra is exposed by taking away the upper part of the vertebral column, and shows such an extension has really taken place. The arch is extremely elongated from behind forwards, the superior or anterior articular process (*a*) has in fact been separated to the extent of several centimeters from the inferior or posterior articular process (*b*), corresponding with the olis-

thesis of the anterior half of the vertebra. The length of the superior or anterior articular process (*a*) is greatly increased, and a corresponding flattening out and secondary deformation (from pressure) of the inferior articular process of the fourth lumbar vertebra may be seen in fig. 21. On comparing fig. 20 with the corresponding pictures of the specimens at Liège and Halle (see Neugebauer, *Archiv für Gynäkologie*, Bd. xx., Hft. 1, fig 29 and fig. 11), we see that the condition of the parts is

Fig. 20.

Fig. 20.—Left half of the sacrum and fifth lumbar vertebra of the Zurich spondylolisthetic pelvis as seen from above (from a photograph).

A sacrum.
B Mana lateralis ossis sacri sinistea.
a Superior articular process.
b Inferior articular processes.
c Interarticular portio of the arch.
d Neck.
e Body.
f Spine.
g Transverse process.
h & *i* Osteophytes projecting from the fifth lumbar vertebra.
c^{x} c^{xx} Portions of the superior articular process (*a*) and interarticular portion (*e*) wasted under pressure.
nn Exposed upper surface of the first sacral vertebra.

exactly similar. Indeed a special description of this Zurich case seems almost superfluous.

In fig. 21 we see that the interarticular portion of the fifth arch has nearly or quite disappeared. Under pressure and tension the wasting and elongation have gone so far that the

lower articular process of the fourth lumbar vertebra and the posterior transverse part of its arch are situated in direct contact with the lateral parts of the first sacral vertebra, so that the body of the latter is driven so far into the sacral aperture of the fifth lumbar vertebra, that it has forced the two segments of this vertebra quite apart, dislocating the anterior segment completely forwards, and interposing itself entirely between them.

The fourth lumbar vertebra lies therefore directly upon the first sacral vertebra, in the interval between the anterior (dislocated) and posterior (stationary) fragments of the fifth lumbar vertebra.

In fig. 22, which represents the same parts *in situ*, one can easily make out the anterior and posterior segments of the arch of the fifth lumbar vertebra, and observe the direct contact between the first sacral vertebra and the fourth lumbar vertebral arch, at the previous situation of the interarticular portion of the arch of the fifth lumbar vertebra.

The fifth lumbar vertebra of the Zurich pelvis is a typical instance of Lambl's dolicho-hyrto-platyspondylus, and its shape gives evidence of the gradual origin of the deformity.

Now what was the origin of the process in this case? Since the continuity of the arch of the fifth lumbar vertebra is not absolutely destroyed on both sides we may exclude the idea of any congenital lateral fissure in the vertebral arch, nor is there any indication of a primary fracture of the sacral articular process. We can therefore only suppose a primary fracture or infraction of the interarticular portions of the arch of the fifth lumbar vertebra. As a matter of fact the arch shows the traces of such an infraction, *i.e.*, dislocation of the fragments, diffuse callus, wasting from pressure, osteophytes, and marks of that insidious process of secondary inflammation.

But one cannot say from the preparation whether there may not have been in this case a secondary infraction of the arch after it had been extremely elongated and compressed under excessive pressure and tension bent into an acute angle, and atrophied that secondary infraction in which the sudden transition takes place from the last stage but one of the deformity into the last, into complete spondyloptosis.

Considering the tens of years that have passed since the *commencement* of the disease, it can easily be understood that

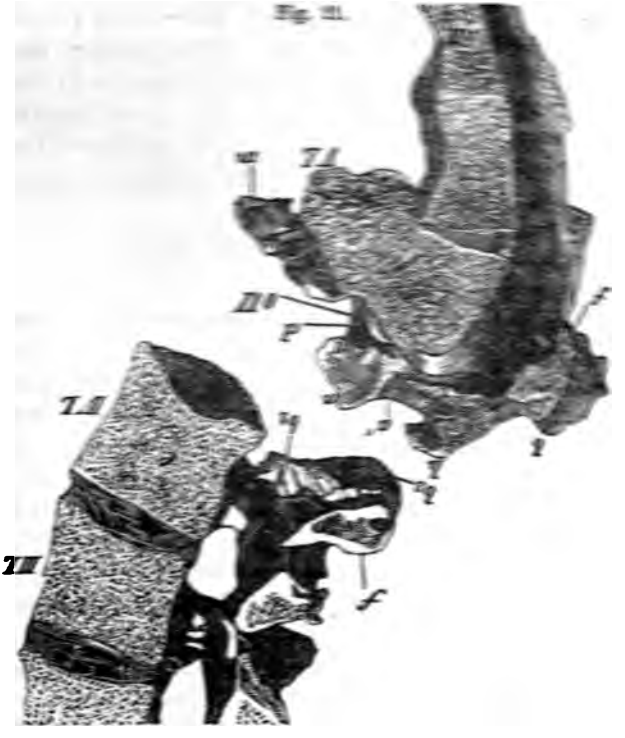


Fig. 21.—View of a median section, from before backwards, of the left half of the lumbo-sacral region of the Zurich pelvis. (From a photograph.)

The fourth lumbar vertebra has been lifted away from the fifth after the ligaments were removed.

III, IV, VI The bodies of the third, fourth, and fifth lumbar vertebræ.

SI, II, III The bodies of the first, second, and third sacral vertebræ.

m Dried up intervertebral disc.

e Body.

f Spine.

a Superior (anterior) articular process (*a'* and *a''* its median and posterior margins) ..... of the fifth lumbar vertebra.

b Inferior (posterior) articular process .....

c Interarticular portion of the arch (wasted *ad maximum* under pressure)

d Pedicle .....

b_1 The articular surface of the inferior articular process of the fourth lumbar vertebra, changed in form and extended in length and breadth by pressure. *f* Fourth lumbar spine. b_2 Posterior part of the inferior articular process (b), and under surface of the posterior transverse portion of its arch; the latter, since resting on the anterior half of the last vertebra it has slipped forward with it, is lying almost directly on the lateral part of the first sacral vertebra.

h Part of the ligamentary attachments which united the fourth and fifth lumbar vertebræ, hardened like an osteophyte; this arising from the fifth arch, surrounds, like a claw, the arch of the fourth lumbar vertebra, which is gradually slipping out of it.

i A tooth-shaped, rudimentary relic of the former interarticular portion of the fifth arch, or a ligamentary mass hardened by ossification.

all traces of primary and of secondary deformation are only too completely confused or blotted out. The question therefore whether there was or was not a primary infraction in the arch of the fifth lumbar vertebra of the Zurich pelvis must remain open for the present. Such probably is the etiology of the case, but it can only be proved in the course of time by a process of exclusion.

Of the 17 specimens of spondyl-olisthetic pelvis known to exist I have had at one time or another an opportunity of examining 10, namely, the two at Prague, Olshausen's case at Halle, that at Breslau, the Prague-Wurzburg case, the second Wurzburg case I have now recorded, that at Munich, those at Paderborn (?) and Zurich, the pelvis of the Hottentot Venus, and besides these ten the two specimens of olisthesis in the penultimate lumbar vertebra lately described at Berlin and Breslau. In reference to the other seven cases the Halle-Giesener one of Blasius appears to be lost, and in this case, as well as in that of the pelvis at Treves, I decidedly doubt the accuracy of the pathological-anatomical diagnosis between spondyl-olisthesis and caries. As to the remaining six pelves, I must confine myself to a consideration of the verbal descriptions which have been given of them, and of the pictures.

My investigations at present have led me to take the following view of the etiology of the so-called spondyl-olisthesis:—

(1) A Congenital Spondyl-olisthesis Interarticularis may exist in the Arch of the Fifth Lumbar Vertebra on one or both sides.*

This mode of origin is certainly indicated anatomically in several cases of the class; for example, in those at Paris and

* In reference to spondyl-olisthesis interarticularis congenita, I would now add to the 59 cases enumerated in my last work (*Archiv für Gynäk.*, Bd. xxi., Heft 2) some new cases that I have met with in Friburg, Basle, Strasburg, and Paris.

No. 60.—Bilateral of the fifth lumbar vertebra, number 0.11.6 of the Friburg Anatomical Museum.

No. 61.—Bilateral of the fifth lumbar vertebra, with separation of the posterior part of the arch into two lateral arches through the spine (*ibidem*).

No. 62.—Bilateral of the fifth lumbar vertebra, unnumbered, in a vertebral column with six sacral and five lumbar vertebra (*ibidem*).

Fig. 22.

Fig. 22.—Internal view of the left half of the lumbar sacral parts of the Zurich pelvis, from a median section (from before backwards) by a saw.

III, *IV*, *V*, Bodies of third, fourth, and fifth lumbar vetebræ.
oIII, *oIV*, *oV*, and *oVI*, The corresponding intervertebral foramina.
o First anterior sacral foramen.
f f Fourth and fifth lumbar spines the former has slipped forwards, so that the latter forms a solitary projection (compare Fr. Billeter, "Ein neuer Fall von hoch gradiger Spondyl-olisthesis des Beckens." *Mang. Diss.*, Zurich, 1862. Tafel III.).
a Superior articular process } of the fifth lumbar vertebra.
b Inferior „ „ }
b' Inferior articular process of the fourth lumbar vertebra.
n Exposed upper surface of the body of the first sacral vertebra.
Isolated spikes of bone (compare *i* in figs. 20 and 21).

No. 63.—Indicated spondyl-olisthesis interarticularis on the right arch of the second lumbar vertebra in the spinal column of a child two or three years old [specimen in spirit] (*ibidem*).

No. 64.—Bilateral of the fifth lumbar vertebra of a female pelvis in the Obstetrical Collection at Basle (from a woman with a funnel-shaped pelvis, who, a primipara 42 years of age, after the delivery with perforation of the head of the child, died on 7th February, 1880). (See Journal, No. 68, 1880.)

No. 65.—Bilateral of a lumbar vertebra.

Bonn, the Prague-Wurzburg pelvis, the second Wurzburg pelvis, and in the two specimens of olisthesis of the penultimate lumbar vertebra, and possibly in the B pelvis at Prague.

Fig. 23.

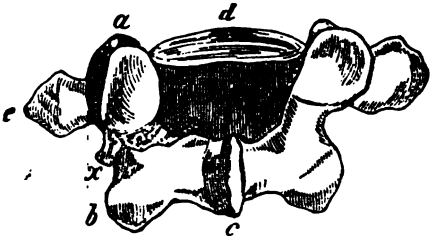


Fig. 23.—Spondyl-olisthesis interarticularis congenita, on the left side of a lumbar vertebra (Strasburg Anatomical Museum, 1880, No. 106). (Compare with the picture Neugebauer, *Archiv. für Gynäk.*, Bd. xx., Heft 1, fig. 16.)

A decision cannot be made, though it would be then a certain one, until consent has been given for separating the fourth lumbar vertebra from the fifth, as I have personally convinced myself may be done without injuring the specimen.

No. 66.—Unilateral (right) of a lumbar vertebra, apparently of the same person (Anatomical Museum at Basle).

No. 67.—Bilateral of the last vertebra of a lumbar column of four vertebræ only (*ibidem*).

No. 68 and 69.—Bilateral of the fourth and fifth lumbar vertebræ, under No. 0. iii. 8, Museum of Pathological Anatomy at Friburg.

No. 70.—Bilateral of a lumbar vertebra under No. 62, 1881 (Anatomical Museum at Strasburg).

No. 71.—Unilateral on the left side, under No. 106, 1880 (*ibidem*), but without bipartition of the spine and middle posterior part of the arch (see fig. 23).

Nos. 72 and 73.—Bilateral of the fourth and fifth lumbar vertebræ in a male, under No. 0. iii. 8, in the Anatomical Museum at Strasburg.

No. 74.—Unilateral on the right side of the fourth dorsal vertebra of the abnormally and perversely ossified special column of a fœtus with sacral spina bifida, hydrocephalus, &c. (*ibidem*).

(Besides these specimens, I found in the Friburg Pathological Museum another fracture of the portio interarticularis of the second lumbar vertebra from a gunshot wound. The body of the vertebra was bisected in the median line, besides which the left half was divided transversely; the whole of the posterior part of the arch was also split off from its spine, so that the vertebra appeared cut into four pieces.)

Finally, I have lately obtained several specimens of spondylolysis, in which the condition varies considerably from the ordinary one.

No. 75.—Bilateral spondylolysis interarticularis congenita in a female pelvis, from the anatomical collection of Professor Farabœuf of Paris. This pelvis exhibits also a complete ossification of the left sacro-iliac ligament.

No. 76.—Fifth cervical vertebra of an adult (see fig. 24); on the left side, close behind the margin of the superior articular process, the arch is traversed by a congenital dividing fissure which gapes to the extent of 1—2 mm., and which divides the surface of the inferior articular process, or so to speak the inferior articular surface, into two parts, an anterior and a posterior segment.

There is therefore a spondylolysis interarticularis only in this case; the inferior articular process is also divided. This variation may perhaps be caused by some anomaly in the ossification of the vertebra. This case calls to mind the one described

I had this day, while visiting the collection in the Jardin des

Fig. 21.

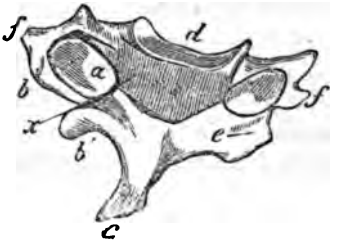


Fig. 24.—Fifth cervical vertebra with a congenital spondylolysis lateralis sinistra of the arch.

a Posterior articular process
b Inferior „ „
b' Posterior portion of the articular surface of the inferior articular process
c Spine
d Body
e Interarticular portion
f Transverse process
x Spondylolysis

} of the fifth cervical vertebra.

Plantes in Paris, the opportunity of personally examining the

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by Gruber (see Neugebauer, *Archiv für Gynäkologie*, Bd. xx., Heft 1, fig. 12), and the spondyloschizis lateralis sinistra of the Prague-Wurzburg pelvis.

Nos. 77 and 78.—Fourth and fifth lumbar vertebræ with an extremely peculiar and unique form of spondylolysis. Whereas in general the fissure traverses the portio interarticularis of the arch, and the spine itself is generally divided into two parts, in this case the posterior span of the arch in both vertebræ with the spine is perfectly developed, but the left inferior articular process of the fourth vertebra, and the left superior of the fifth, is formed of one single piece of bone. The condition of the surfaces of separation of the central parts and the external appearance are direct evidence of a congenital condition.

The peripheral parts of this specimen, that is to say, the two isolated articular processes, have unfortunately been destroyed. The fifth lumbar vertebra is depicted in fig. 25.

No. 79.—Fifth lumbar vertebra of a child about ten years old, in which the posterior half of the arch on the right side is an isolated piece of bone, united by ligamentary bands with the right interarticular portion, and with the pedicle of the spine on the left side.

No. 80.—Fifth lumbar vertebra, with bilateral congenital interarticular fissure. Many of the last preparations are derived from the private stores of the servants of different anatomical institutions, where so many interesting specimens, carelessly thrown aside, are destined to be worked up into some heterogeneous skeleton or other. I also found some specimens among the vertebra in the collections of the Parisian dealers in natural history specimens.

No. 81.—Bilateral interarticular spondyloschizis (the congenital nature of which cannot be absolutely insisted on, because of some unfortunate fractures) in one of the lumbar vertebra, which I found about three weeks ago during an inspection of the

skeleton of the Hottentot Venus, who died in Paris on 1st January, 1816, at the age of 38, and must agree completely with the opinions of Hennig and Lambl, that it is a case of spondyl-olisthesis, but that it would probably never have reached a higher degree if no further pregnancy had occurred to promote it. If the superior articular process on each side is placed perpendicularly above or immediately in front of the inferior, the separated halves of the vertebral arch cannot be placed in contact, but

Fig. 25.

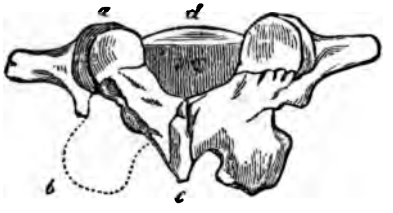

Fig. 25.—Fifth lumbar vertebra, with a defect in the ossification between the arch and left inferior articular process. The latter (*b*) forms in the specimen an isolated piece of bone.

stand somewhat apart. There is therefore some elongation of the interarticular portion, and the body of the fifth lumbar vertebra must during life have been displaced forwards, as is also proved to have been the case by the depression and grinding away of the anterior edge of the body of the first sacral vertebra, and the condition of the lumbar spines, which show there was a considerable lumbar lordosis with a corresponding position of the body of the fifth lumbar vertebra.

(2) Fracture of the Articular Processes of the Sacrum.

This mode of origin also is absolutely proved anatomically by the specimen of spondyl-olisthesis lumbo-sacralis at Breslau,

bony treasures stored up in the Catacombs of Paris, in company with Dr. Bonnaire, Interne of the Paris Maternity, where so many interesting pathological specimens have been found.

No. 82.—Bilateral congenital spondyloschizis interarticularis vert. lumbalis, *V.*, in the skeleton set up *à la Beauchène* in the Museum of the Amphithéâtre des Hospiteaux in Paris.

In any case, the important series of 82 observations of these lateral fissures in the vertebra, which manifest such numerous variations, will help to develop the historical knowledge of the manner of ossification of the vertebra. Unfortunately up to the present time this question has been very imperfectly investigated, and it is desirable *that some embryologist* or histologist should undertake it, as an independent work.

described first by Strasser, and afterwards by myself, and was I believe the mode of origin in the Paderborn pelvis.

In these cases one may speak of a dislocation of the last lumbar vertebra as a whole, for as sure as the sacral articular processes are broken under the action of the body weight the fragments cracked off the arch of the fifth lumbar vertebra supported by them, and therefore the whole of the last lumbar vertebra slips a little forwards. But this movement soon ceases, for the fragments broken off the articular processes are arrested by the posterior edge of the upper surface of the body of the first sacral vertebra, and with this arrest the displacement of the fifth lumbar vertebra *in toto* is put an end to, and it is only the anterior half of this vertebra, as in the other cases, that now continues to slip forwards under the mechanical conditions of its present position.

(3) Primary Lateral Fracture of the Arch of the Fifth Lumbar Vertebra.

This is anatomically evident in the Munich pelvis, and may be suspected in many other cases, probably was so in the B pelvis at Prague, unless this was a case of congenital spondyl-olisthesis. In reference to this, the third mode of origin, there are still many points to be discussed.

In the first place, it is certain that in many cases of complete spondyloptosis, the highest degree of olisthesis—and fortunately it is only such pelves for the most part which reach the museums in consequence of deaths in labour directly due to the spondyloptosis—the fifth lumbar vertebra is closely united to the sacrum by synostosis, and their anatomical investigation is very difficult. The lumbo-sacral articulation must be most carefully examined for any fracture, especially for any fracture of the sacral articular processes such as that in the Breslau pelvis. Unfortunately this endeavour is generally unsuccessful, for these lumbo-sacral articular processes are for the most part completely united by synostosis, so that no fracture can be proved by appearances. The shape, that is the antero-posteror extension of the articular surfaces of the lumbo-sacral joint, always gives a certain amount of evidence, and where a primary fracture of the sacral articular processes has taken place, the lumbar articular processes seen

from above are abnormally elongated in proportion to the interval between the fragments. For example, in the Paderborn pelvis I believe that a primary fracture of the sacral articular processes has occurred, because the lumbar articular processes are drawn out to a most unusual length, so that the entire posterior transverse span of the arch of the fifth lumbar vertebra, in consequence of this elongation of its inferior articular processes, an elongation which, as already mentioned, corresponds to the degree of the interval between the fragments of the broken sacral articular processes, is moved somewhat forward. And as regards the pelvis at Halle and the A pelvis at Prague, I have already stated my belief that this primary fracture of the sacral articular processes, which unfortunately from the extensive synostosis in both cases is unsupported, except by the elongation of the inferior lumbar processes, was the mode of their origin. Be this as it may, there is still a very important question to decide. If a fracture or infraction in the interarticular portion of the arch of the fifth lumbar vertebra has evidently taken place in a pelvis, was this fracture or infraction, as the case may be, primary or secondary? The mode of origin of the secondary infraction, at the moment when elongation of the arch of the fifth lumbar vertebra having already reached a maximum, on the occasion of some sudden forcible strain, while the upper trunk is bent over forwards, the body of the fifth lumbar vertebra is tilted completely over, forwards and downwards, and passes out of the third stage of olisthesis of Lambl into the fourth stage, that of complete ptosis, is perfectly comprehensible, and my theory of it has not as yet been opposed. Now this question is a most difficult one. According to the principles of mechanics, secondary infraction is certainly more probable than primary. But whether the infraction is always secondary is a question that cannot be at present settled, the less so as there certainly are cases in which the spondyloptosis, the complete tilting over of the body of the fifth lumbar vertebra, takes place quite gradually without any infraction of the arch.

On the other hand, it is proved by several pathological anatomical preparations that a primary fracture of the interarticular portion of the vertebral arch does sometimes occur. Those cases, therefore, in which there has not been any congenital spondylolysis interarticularis, and no fracture of the sacral articular

processes can be pointed out, where in fact these processes are unaltered, nothing can be supposed except this questionable primary fracture of the arch of the fifth lumbar vertebra until we can find some other mode of origin of spondyl-olisthesis; and indeed this supposition seems to be the more justifiable, for *it is admitted that in by far the greater number of cases the anamnesis gives evidence that the spondyl-olisthesis commenced in a fracture.* If the entire posterior transverse span of the arch of the fifth lumbar vertebra is still in its normal place, that is, not displaced forwards, and if it is either not ossified on to the sacral articular processes, or if it be, if there is no elongation in the inferior lumbar articular processes from behind forwards, we may then suppose a primary fracture of the interarticular portion of the arch of the fifth lumbar vertebra (no congenital spondylolysis existing at this place); but if the entire posterior transverse span of the arch of the fifth lumbar vertebra has moved forwards with the rest, and if its inferior articular process exhibits an elongation from tensions corresponding with this forward movement, I think that the idea of a primary fracture in the sacral articular processes with separation of the fragments from each other is more justifiable.

Summarising what has been said, we may formulate the etiology of spondyl-olisthesis at the present time as follows—

Olisthesis may exist—

(1) On the ground of congenital lateral defect in the ossification of one or both sides of the arch of the fifth lumbar vertebra, especially in the interarticular portion of the arch (spondyloschizis interarticularis congenita arcus vertebralis).

(2) On the ground of a primary fracture—

(*a*) Of the sacral articular processes, if the posterior transverse span of the arch of the fifth lumbar vertebra is displaced forwards, and its inferior articular process exhibits a corresponding antero-posterior elongation.

(*b*) Of the interarticular portion of the arch of the fifth lumbar vertebra, if the posterior transverse span of the arch is not displaced forwards, but has remained in its normal position, and whether the lumbo-sacral joint is ankylosed or not.

It lies with anatomists and pathological anatomists, a

those who make surgical and forensic post-mortems to look out for the early stages of spondyl-olisthesis in all fatal cases of injury from falling. If this is done, I am sure that before very long commencing or advanced spondyl-olisthesis lumbo-sacralis will be occasionally discovered during the examination of dead bodies at various places.

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